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RESEARCH MEMORANDUM

EXPERIMENTAL AERODYNAMIC FORCES AND MOMENTS AT LOW SPEED OF A MISSILE MODEL DURING SIMULATED LAUNCHING FROM THE MIDSEMISPAN LOCATION OF A 45° SWEPTBACK WING-FUSELAGE COMBINATION

By William J. Alford, Jr., H. Norman Silvers, and Thomas J. King, Jr.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
WASHINGTON
February 4, 1955

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EXPERIMENTAL AERODYNAMIC FORCES AND MOMENTS AT LOW SPEED OF A MISSILE MODEL DURING SIMULATED LAUNCHING FROM THE MIDSEMISPAN LOCATION OF A 45° SWEPTBACK WING-FUSELAGE COMBINATION

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SUMMARY

An investigation was made at low speed to determine the aerodynamic forces and moments of a missile model during simulated launching from the midsemispan location of a 45° sweptback wing-fuselage combination, including the effects on the missile forces and moments of a pylon support.

The results of this investigation indicated that change in chordwise position of the missile below the wing of a wing-fuselage combination produced large changes in the missile aerodynamic forces and moments, with these changes becoming larger as the angle of attack was increased. Moving the missile forward longitudinally, so that its center of gravity moves ahead of the wing leading edge, reduced the changes in missile forces and moments induced by the wing-fuselage combination; and when the missile reaches a distance of approximately 1.5 wing chords ahead of the wing leading edge, its characteristics tend to be the same as those of the isolated missile. Moving the missile center of gravity vertically from the wing-chord plane also reduced the induced changes, although the degree of reduction is a function of the missile longitudinal location. The addition of a flat-sided pylon to the missile wing-fuselage combination had no important effects on any of the missile forces and moments except on the rolling moments which were increased for the missile positions in close proximity to the wing.

INTRODUCTION

The National Advisory Committee for Aeronautics is conducting investigations to determine the nature and origin of the mutual interference effects experienced by various wing-fuselage models and various types of external stores. Previous investigations (refs. 1 to 3) have shown the existence of these generally objectionable interference effects, and reference 4 has shown that they are primarily due, at low speeds, to the nonuniform flow field generated in the vicinity of the model.

This paper presents a detailed coverage of the aerodynamic forces and moments of a typical missile model during simulated launching from the midsemispan location of a 45° sweptback wing-fuselage combination. Some brief results of this investigation were previously published in reference 4.

SYMBOLS

N	missile normal force, lb
m	missile pitching moment, ft-lb
A	missile axial force, lb
Y	missile side force, lb
n	missile yawing moment, ft-lb
l	missile rolling moment, ft-lb
C_N	missile normal-force coefficient, $\frac{N}{qS_m}$
C_m	missile pitching-moment coefficient, $\frac{m}{qS_m\bar{c}_m}$
C_A	missile axial-force coefficient, $\frac{A}{qS_m}$
C_Y	missile side-force coefficient, $\frac{Y}{qS_m}$
C_n	missile yawing-moment coefficient, $\frac{n}{qS_m b_m}$
C_l	missile rolling-moment coefficient, $\frac{l}{qS_m b_m}$
C_{L_W}	lift coefficient of wing-fuselage combination, $\frac{\text{Lift}}{qS}$

q	free-stream dynamic pressure, lb/sq ft
V_o	free-stream velocity, ft/sec
S_m	exposed missile wing area of two panels, 0.046 sq ft
S	airplane model wing area, 6.25 sq ft
b_m	span of missile wing, 0.415 ft
b	wing span of airplane model, 5 ft
c	local wing chord of airplane model, ft
$\bar{c}_m$	mean aerodynamic chord of exposed missile wing area (two panels), 0.189 ft
x	chordwise distance from leading edge of the local wing chord to the missile center of gravity (positive rearward), ft
y	spanwise distance from fuselage center line to missile center line (positive to the right), ft
z	vertical distance from wing-chord plane (positive upward), ft
d_m	diameter of missile body, 1.08 in.
α	angle of attack, deg

MODELS AND APPARATUS

The wing-fuselage combination used as the test vehicle was strut-mounted (fig. 1) and its wing quarter-chord line was swept back 45° and was of aspect ratio 4.0, taper ratio 0.3, and employed NACA 65A006 airfoil sections parallel to the free-stream direction. The fuselage consisted of an ogival nose section, a cylindrical center section, and a truncated tail cone. A two-view drawing of the wing-fuselage combination as part of the test setup is shown in figure 2, and the fuselage ordinates are presented in table I. The ordinates of a flat-sided pylon also utilized in the investigation are presented in table II.

The missile model used in this investigation employed a cruciform arrangement of its wing and tail and is shown in figure 2 as part of the test setup with its general proportions being shown in figure 3.

Tests of the isolated missile and its component parts were made in the free stream. Figure 1 presents a photograph of the test setup. The missile was internally instrumented with a six-component strain-gage balance and was supported from the rear of the wing-fuselage combination by a sting that was adjustable in the longitudinal, lateral, and vertical planes (fig. 2). The missile center line was located at the 0.50 semispan station of the wing-fuselage combination for numerous chordwise and several vertical locations.

TESTS AND CORRECTIONS

The tests were made in the Langley 300 MPH 7- by 10-foot tunnel at an airstream velocity of 100 miles per hour, a dynamic pressure of 25.5 pounds per square foot, and a Reynolds number of 0.92×10^6 per foot of a typical dimension. This paper presents the aerodynamic forces and moments of a missile model during simulated launching from the midsemispan location of a 45° sweptback wing-fuselage combination. The angle-of-attack range generally extended from -8° to 28° at zero sideslip.

The missile was tested under the left wing of the test vehicle, which was inverted so as to avoid the support-strut interference (fig. 1). The direction of positive forces and moments is shown in figure 4.

In most instances the missile forces and moments were obtained with no supporting pylon installed. The effects of the presence of a flat-sided pylon were investigated, however, with the gap between the missile and the pylon both sealed and unsealed.

Blocking corrections calculated by the method of reference 5 were applied to the dynamic pressure.

Jet-boundary corrections calculated by the method of reference 6, along with a free-stream misalinement angle of 0.2°, have been applied to the angle of attack when the wing-fuselage combination influenced the test results. For the isolated-missile tests, only the misalinement correction was applied.

A study of the missile strain-gage balance calibrations and general repeatability of the data indicated that the accuracy levels of the various force and moment coefficients are approximately as follows:

Component	Accuracy
C_N	±0.02
C_m	±0.02
C_Y	±0.02
C_n	±0.01
C_l	±0.005
C_A	±0.005

RESULTS AND DISCUSSION

The aerodynamic characteristics of the isolated missile at low speed, as determined from breakdown tests in the free stream, are presented in figure 5. The missile forces and moments, as affected by the wing-fuselage combination at a maximum of nine chordwise locations and for three vertical heights, are presented as functions of angle of attack in figure 6. The effects of a pylon on the missile forces and moments in the presence of the wing-fuselage combination are presented in figure 7, and summary data in the form of missile forces and moments as a function of chordwise location for constant angles of attack are presented in figure 8. The lift characteristics of the isolated wing-fuselage combination are presented for orientation in figure 9.

An inspection of figures 6 and 8 indicates that changes in the chordwise location of the missile as it passes through the wing-fuselage flow field produced large changes in the forces and moments of the missile in both the longitudinal and lateral planes with no pylon installed. As would be expected, the changes in the aerodynamic forces and moments of the missile induced by the wing-fuselage combination diminish as the missile center of gravity is moved ahead of the wing; and when it reaches a distance of approximately 1.5 wing chords ahead of the wing leading edge, the missile forces and moments tend to be the same as those of the isolated missile (figs. 5, 6, and 8).

The effects of changes in the vertical position of the missile are also shown in figures 6 and 8. In general, as the missile is moved away from the wing-chord plane, the changes induced by the presence of the wing-fuselage combination are seen to be reduced, although the degree of reduction is a function of the missile longitudinal location.

As the angle of attack is increased, the induced effects are also increased. This can be explained (see ref. 4) by the increase in wing circulation strength which results in strengthened and expanded downwash and sidewash angularity fields in conjunction with a nonuniform dynamic-pressure field.

In order to investigate the effects of a pylon on the missile forces and moments, a flat-sided pylon (table II) was utilized. The main effects produced by the pylon (fig. 7) were slight displacements in the curves of pitching moment against angle of attack and an increase in the rolling moments for the missile positions in close proximity to the wing. These results were rather surprising, since it was expected that the pylon mounted on the swept wing also would produce sidewash effects that would cause changes in the missile side-force and yawing-moment characteristics. Since a gap had to be maintained between the missile and the pylon to avoid fouling, it was suspected that this gap was producing some relieving effect. In order to check possible gap effects, a thin rubber membrane was installed between the missile and the pylon to provide a seal. The results obtained with this arrangement are presented in figure 7(b) for comparison with the corresponding seal-off configuration. As can be seen, only minor variations were incurred and it is not definitely understood whether these variations were the result of sealing the gap or of some seal stressing effects. In either event, the changes are small and it is presumed that the gap had no appreciable effect.

The influence of the pylon is expected to be substantially larger at speeds where compressibility effects become important; therefore, caution should be exercised in using the results of this investigation to estimate missile forces and moments at higher speeds.

CONCLUSIONS

The results of an investigation at low speed of the aerodynamic forces and moments of a missile model during simulated launching from the mid-semispan location of a 45° sweptback wing-fuselage combination, with and without a supporting pylon installed, indicate the following conclusions:

1. Change in chordwise position of the missile below the wing of a wing-fuselage combination produced large changes in the missile aerodynamic forces and moments, with these changes becoming larger as the angle of attack was increased.

2. Moving the missile forward longitudinally, so that its center of gravity moves ahead of the wing leading edge, reduced the changes in missile forces and moments induced by the wing-fuselage combination; and when the missile reaches a distance of approximately 1.5 wing chords ahead of the wing leading edge, its characteristics tend to be the same as those of the isolated missile. Moving the missile center of gravity vertically from the wing-chord plane also reduced the induced changes, although the degree of reduction is a function of the missile longitudinal location.

3. The addition of a flat-sided pylon to the missile wing-fuselage combination had no important effects on any of the missile forces and moments except the rolling moments which were increased for the missile positions in close proximity to the wing.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., November 4, 1954.

REFERENCES

1. Alford, William J., Jr., and Silvers, H. Norman: Investigation at High Subsonic Speeds of Finned and Unfinned Bodies Mounted at Various Locations From the Wings of Unswept- and Swept-Wing–Fuselage Models, Including Measurements of Body Loads. NACA RM L54B18, 1954.

2. Silvers, H. Norman, and King, Thomas J., Jr.: Investigation at High Subsonic Speeds of Bodies Mounted From the Wing of An Unswept-Wing–Fuselage Model, Including Measurements of Body Loads. NACA RM L52J08, 1952.

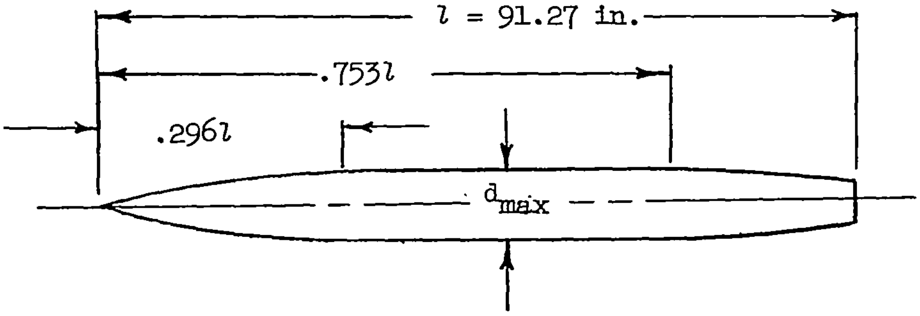
3. Silvers, H. Norman, and Alford, William J., Jr.: Investigation at High Subsonic Speeds of the Effect of Adding Various Combinations of Missiles on the Aerodynamic Characteristics of Sweptback and Unswept Wings Combined With a Fuselage. NACA RM L54D20, 1954.

4. Alford, William J., Jr., Silvers, H. Norman, and King, Thomas J., Jr.: Preliminary Low-Speed Wind-Tunnel Investigation of Some Aspects of the Aerodynamic Problems Associated With Missiles Carried Externally in Positions Near Airplane Wings. NACA RM L54J20, 1954.

5. Herriot, John G.: Blockage Corrections for Three-Dimensional-Flow Closed-Throat Wind Tunnels, With Consideration of the Effect of Compressibility. NACA Rep. 995, 1950. (Supersedes NACA RM A7B28.)

6. Gillis, Clarence L., Polhamus, Edward C., and Gray, Joseph L., Jr.: Charts for Determining Jet-Boundary Corrections for Complete Models in 7- by 10-Foot Closed Rectangular Wind Tunnels. NACA WR L-123, 1945. (Formerly NACA ARR L5G31.)

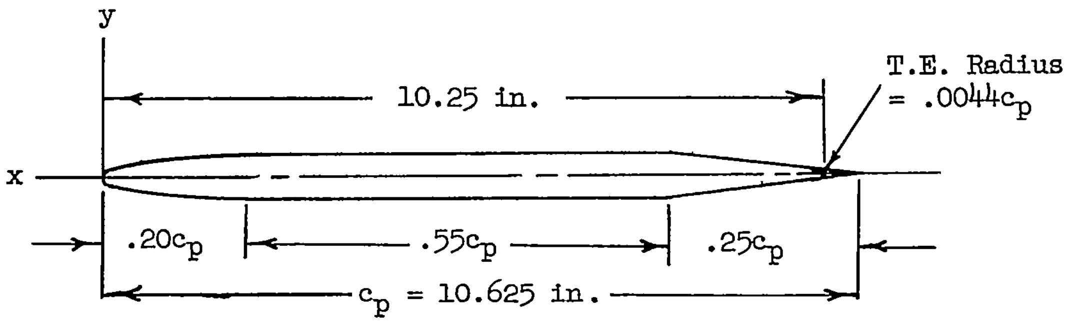
TABLE I.- FUSELAGE ORDINATES



Ordinates, percent length	
Station	Radius
0	0
3.28	.91
6.57	1.71
9.86	2.41
13.15	3.00
16.43	3.50
19.72	3.90
23.01	4.21
26.29	4.43
29.58	4.57
75.34	4.57
76.69	4.54
79.98	4.38
83.26	4.18
86.55	3.95
89.84	3.72
93.13	3.49
96.41	3.26
100.00	3.02

TABLE II.- FLAT-SIDED PYLON ORDINATES

[Basic thickness ratio, 6.0 percent; actual thickness ratio, 6.2 percent, based on actual chord length of 10.25 inches]



Ordinates, percent chord	
X	Y
0	0
2.5	±1.46
5.0	±2.00
15.0	±2.90
20.0	±3.00
75.0	±3.00
Straight taper	
100.0	0

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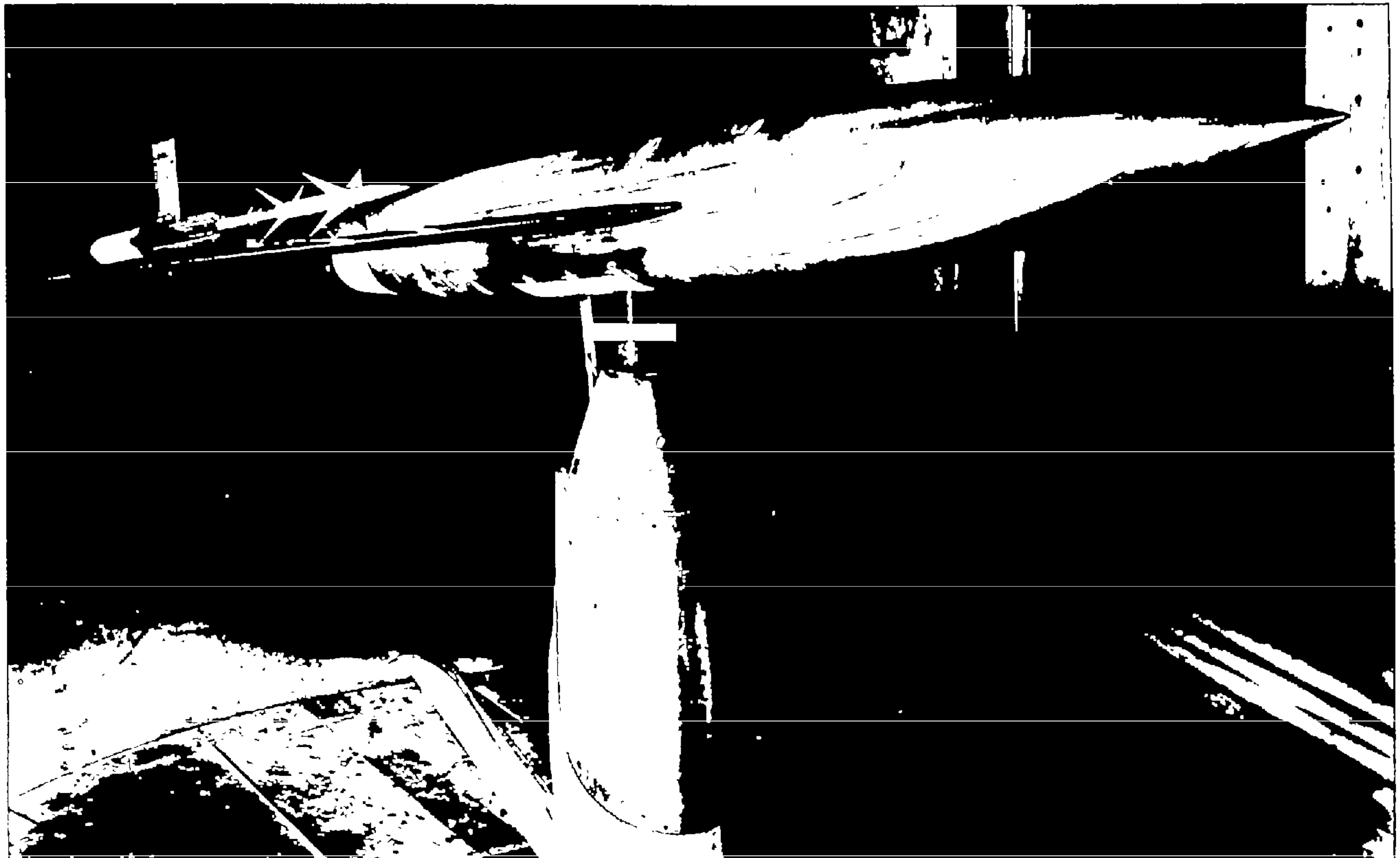

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Figure 1.- Photograph of test setup of model showing the missile installed.

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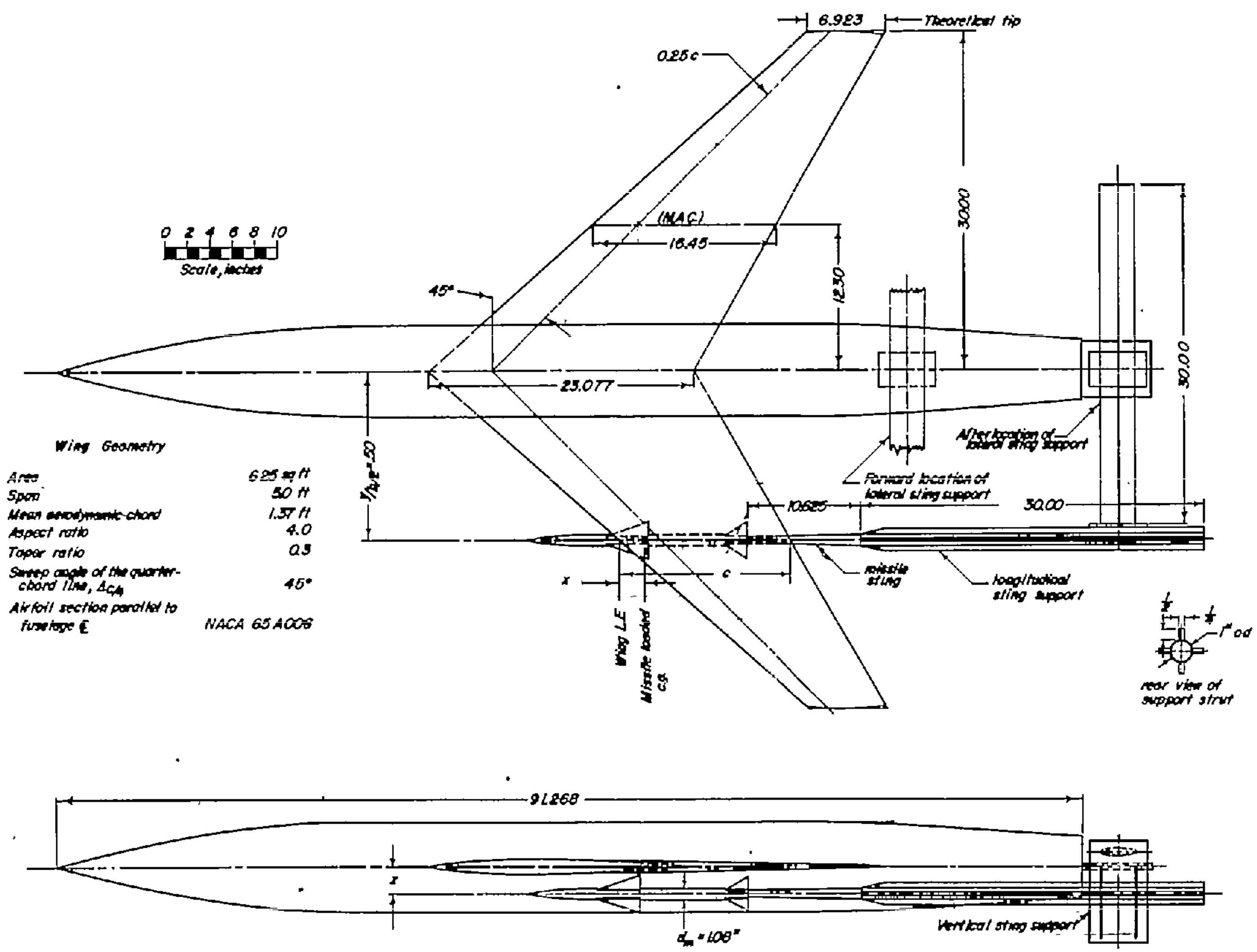

Figure 2.- Test setup showing missile in one test location. All dimensions are in inches.

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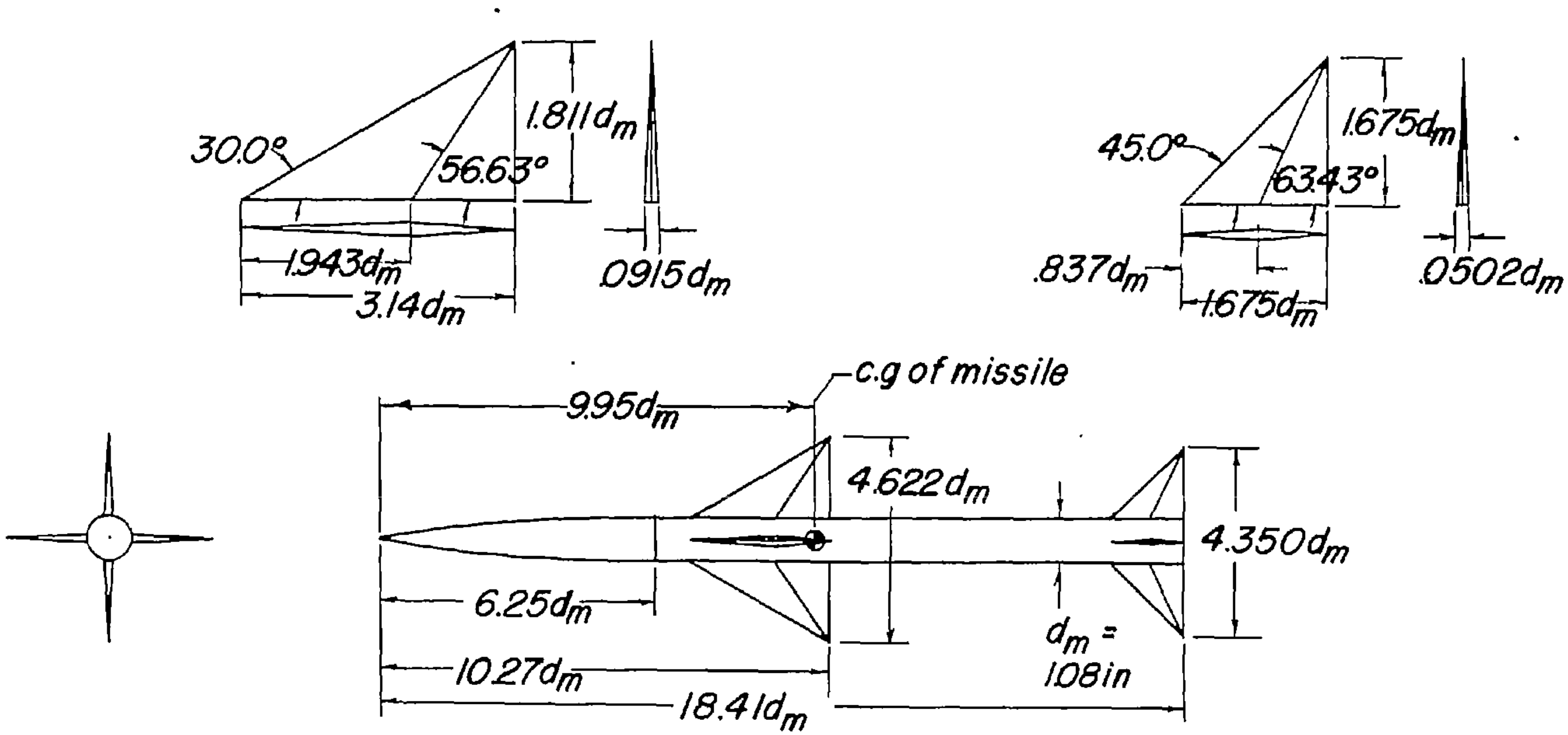

Figure 3.- Drawing of missile model showing general proportions.

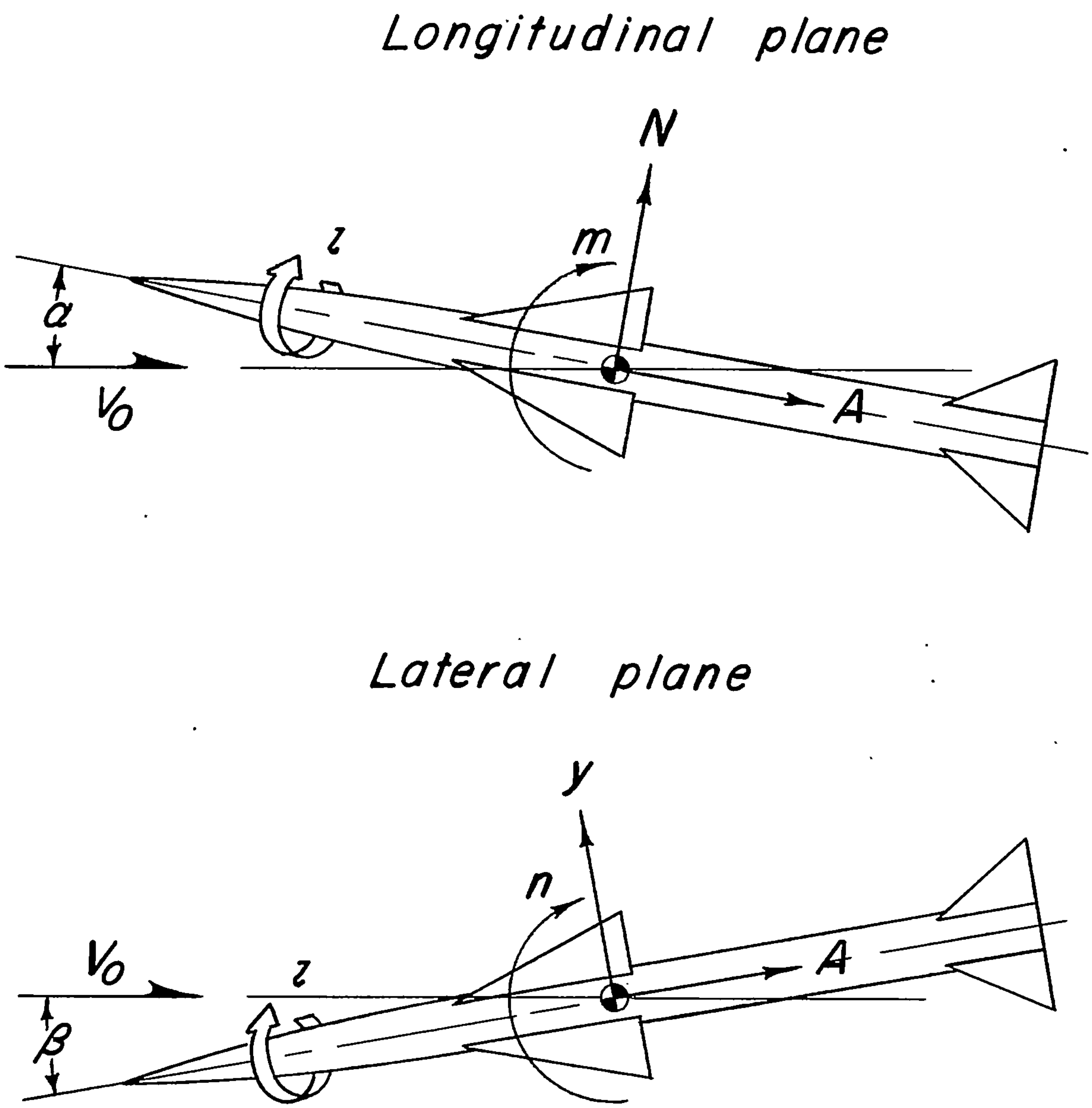

Figure 4.- Positive directions of forces and moments as measured on the missile.

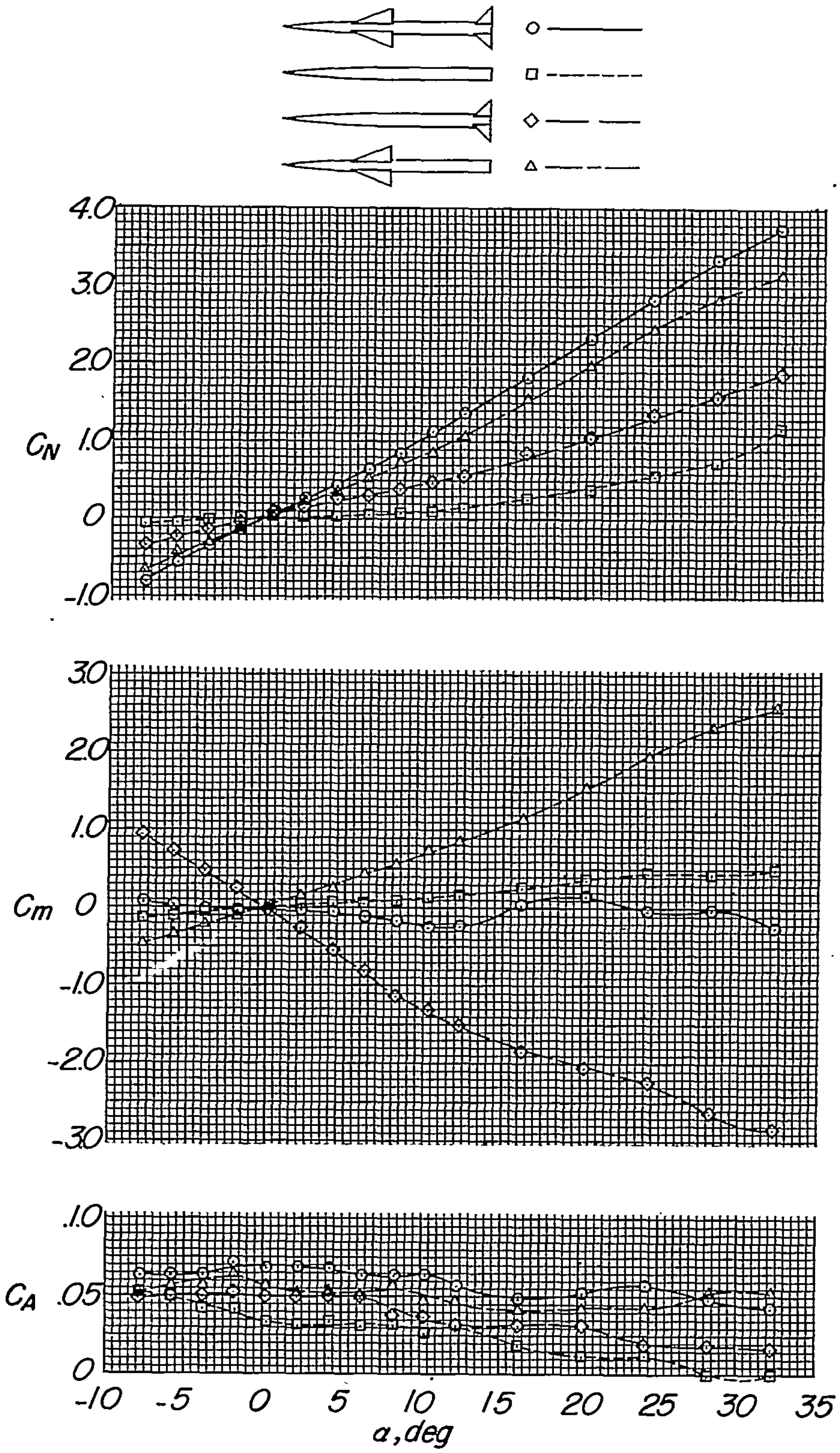

Figure 5.- Isolated missile and missile component characteristics.

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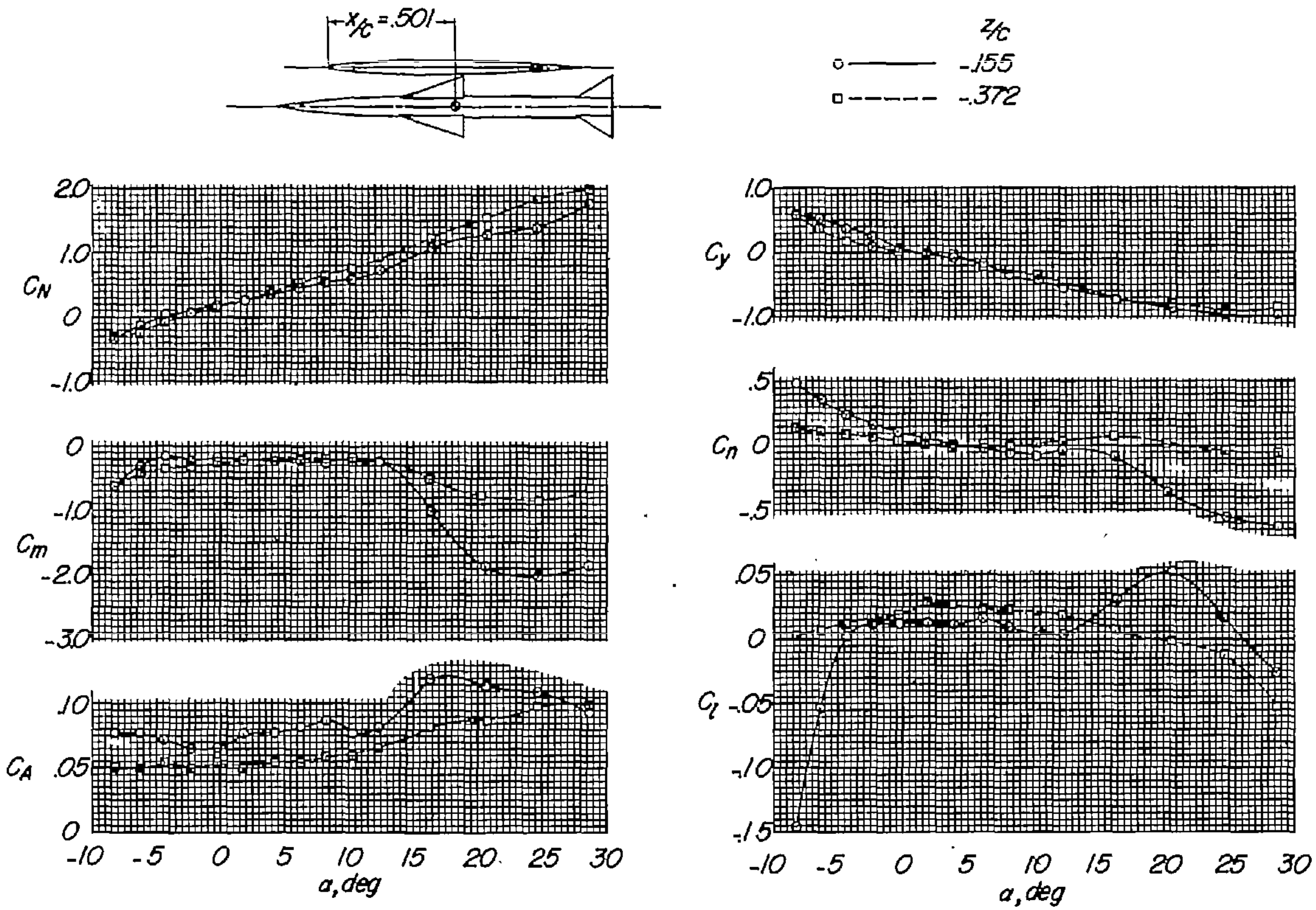

(a) x/c = 0.501.

Figure 6.- Missile aerodynamic forces and moments in the presence of wing-fuselage combination at various vertical heights.

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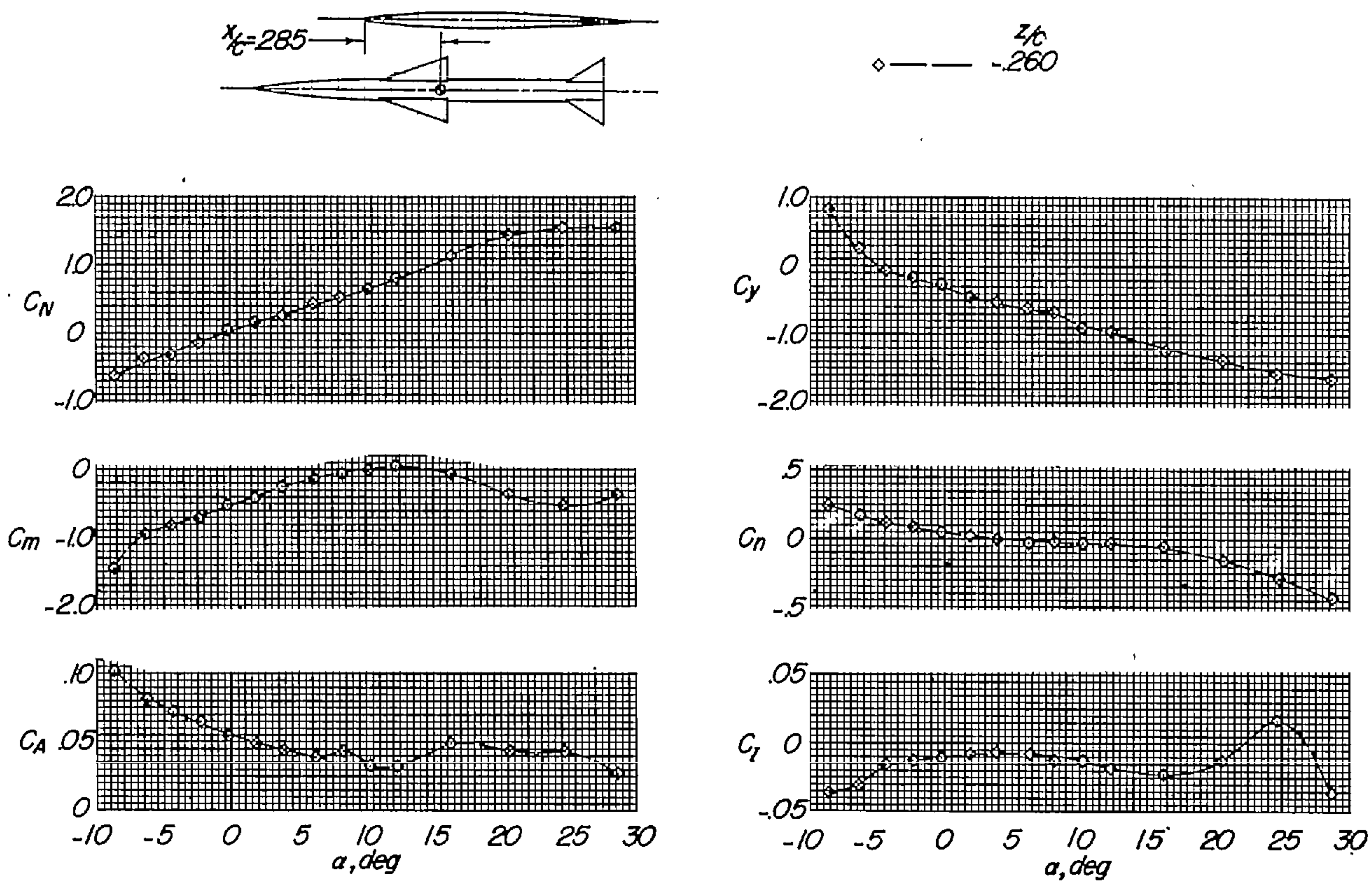
[redacted]



(b) x/c = 0.285.

Figure 6.- Continued.

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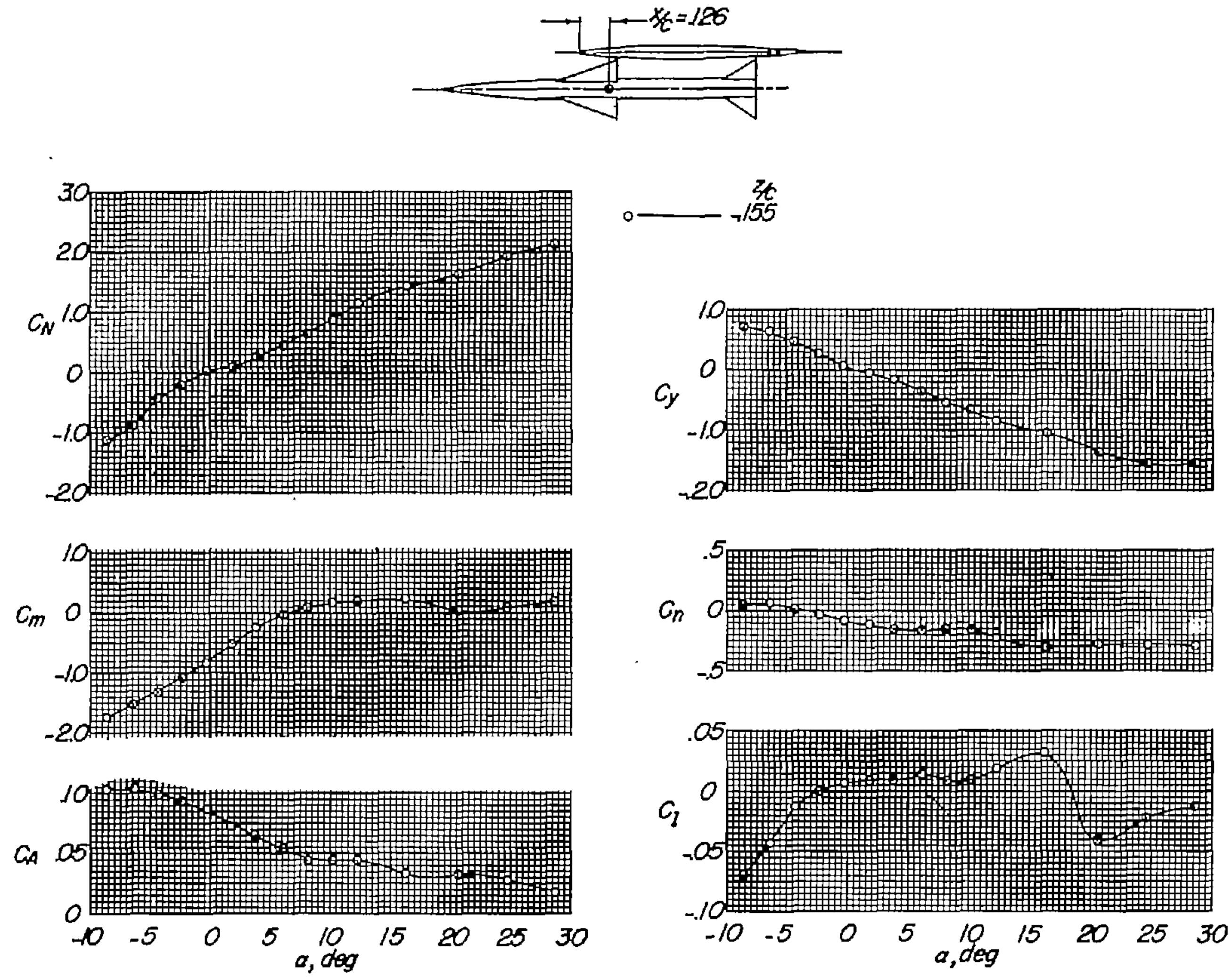
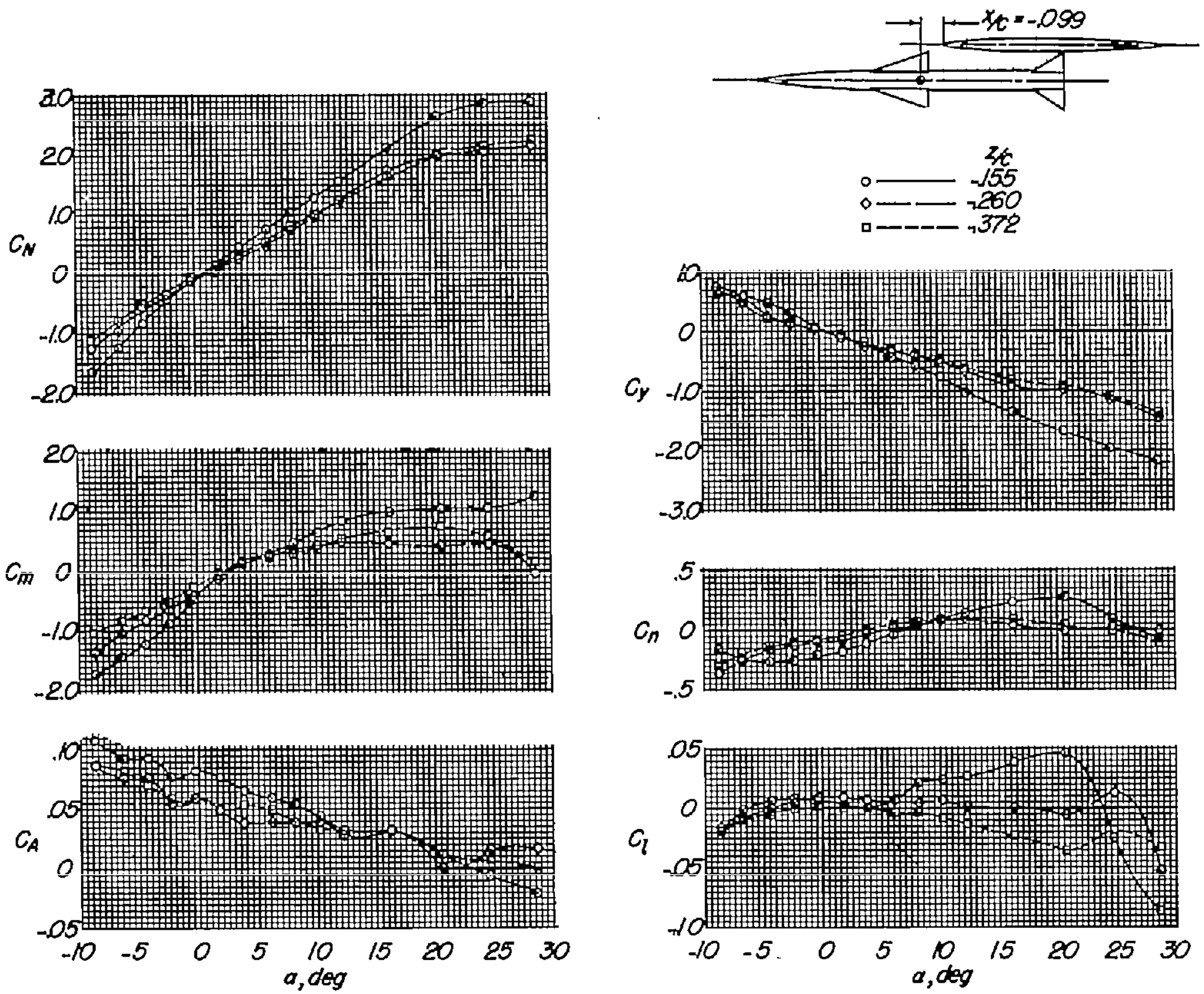


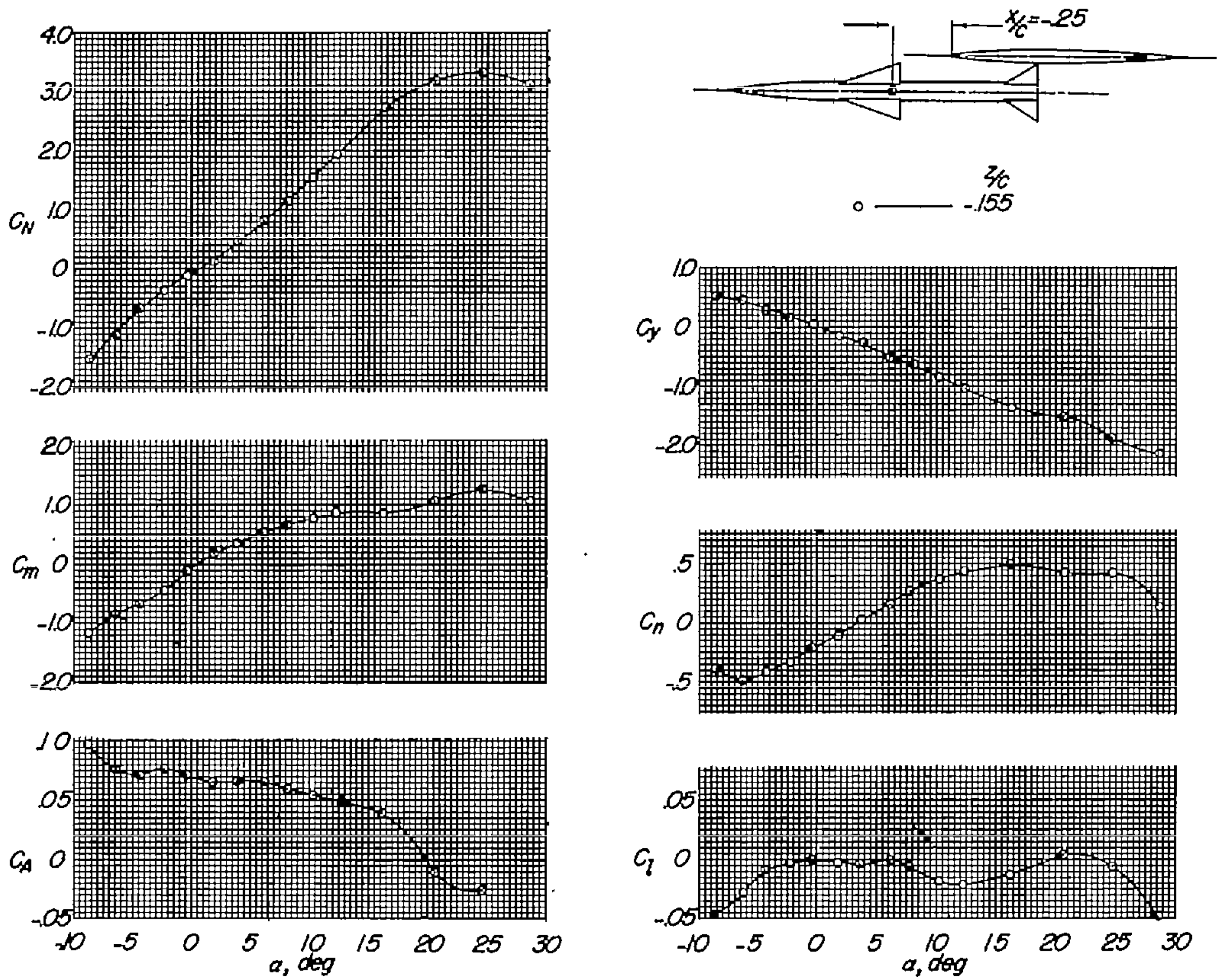
(c) $x/c = 0.126$.

Figure 6.- Continued.



(d) x/c = -0.099.

Figure 6.- Continued.



(e) x/c = -0.25.

Figure 6.- Continued.

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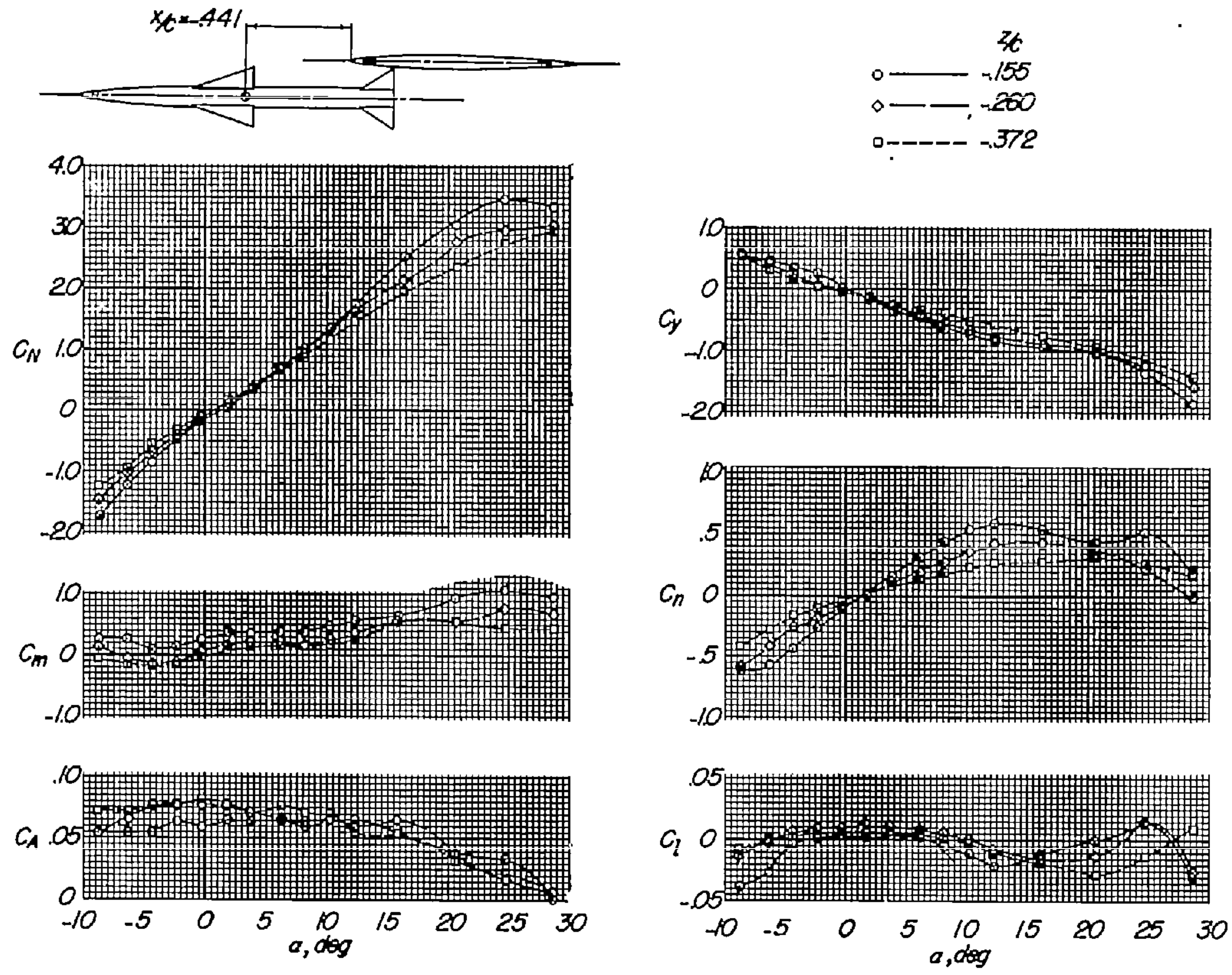

(f) x/c = -0.441.

Figure 6.- Continued.

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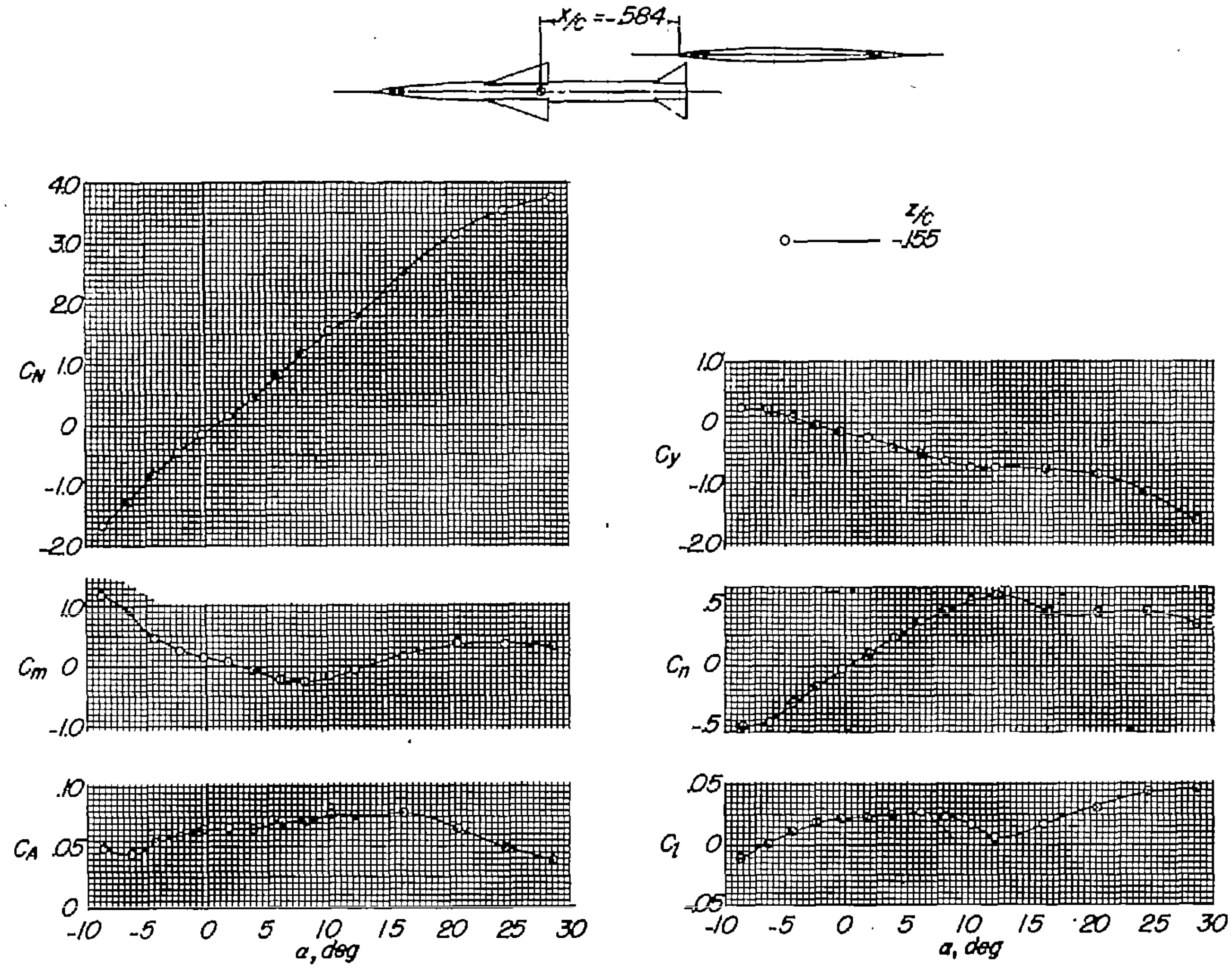

(g) x/c = -0.584.

Figure 6.- Continued.

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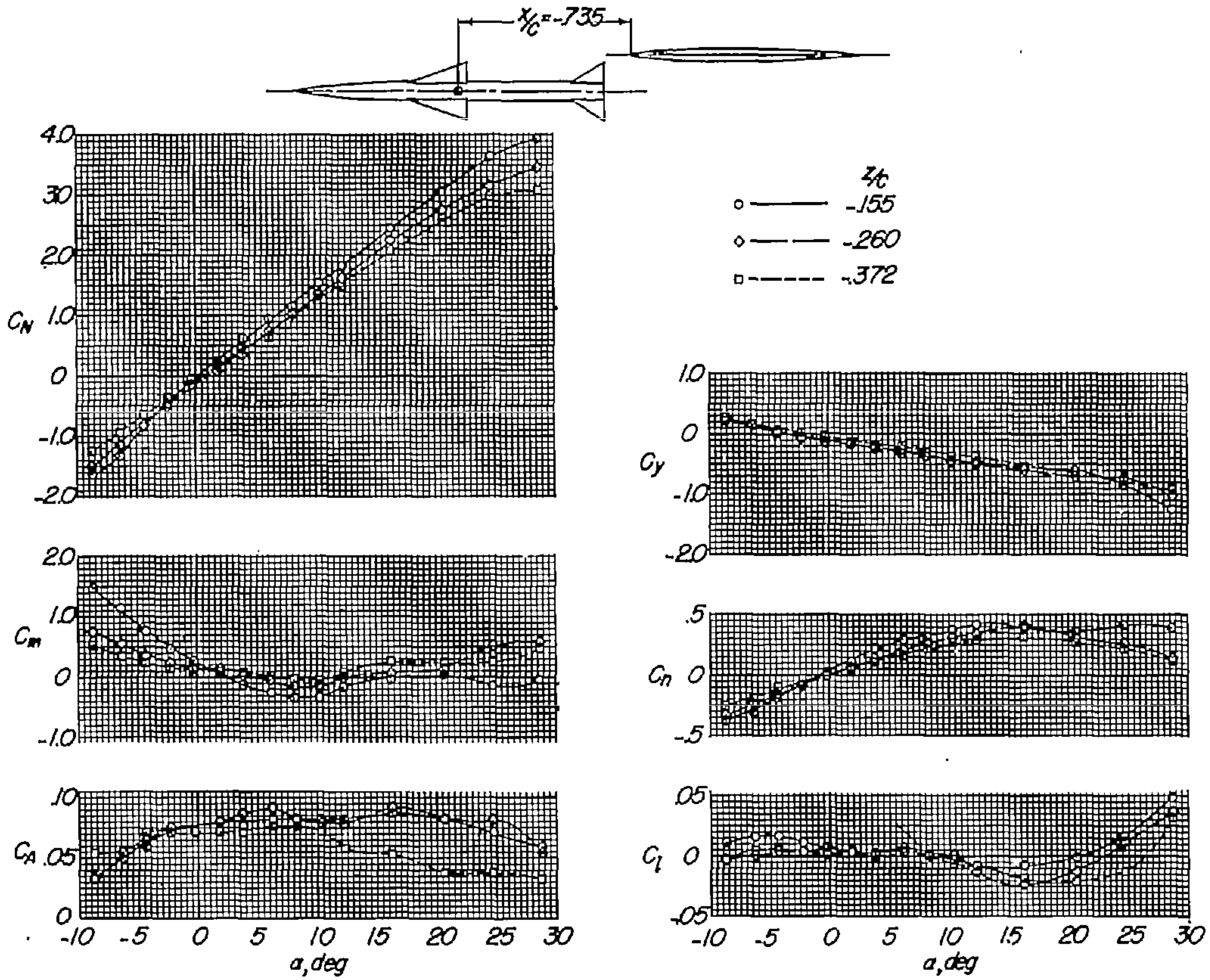

(h) x/c = -0.735.

Figure 6.- Continued.

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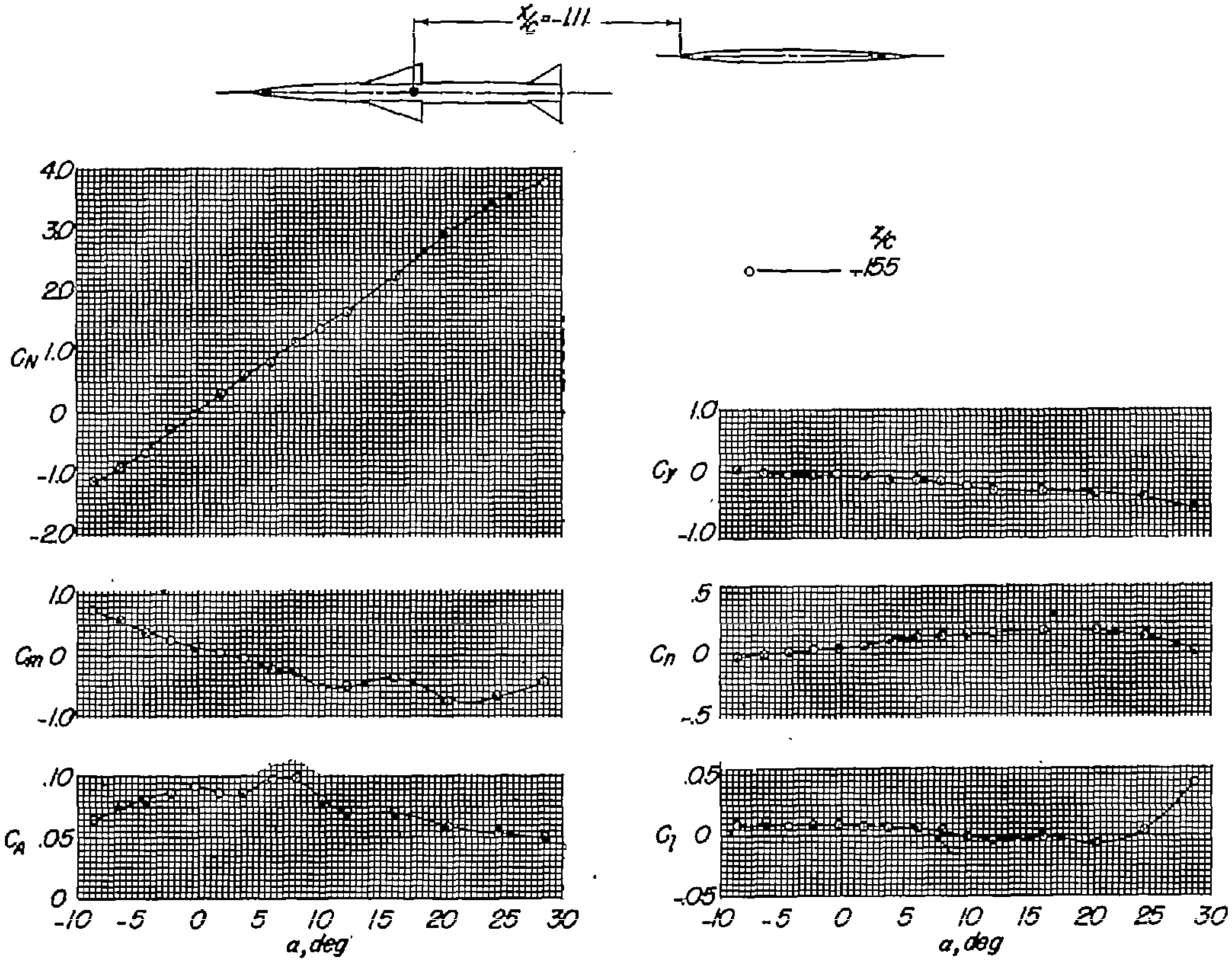

(i) x/c = -1.11.

Figure 6.- Continued.

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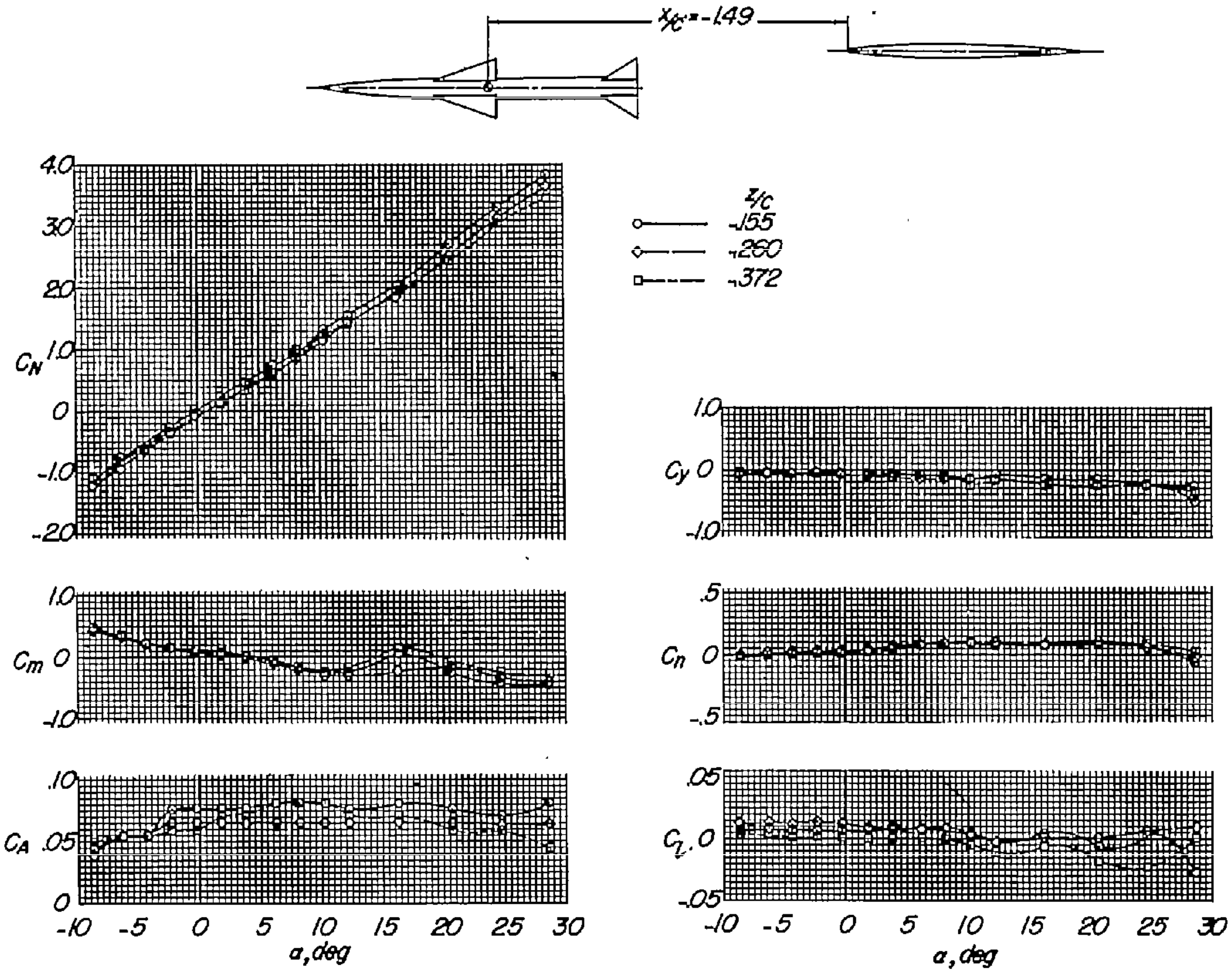

(j) x/c = -1.49.

Figure 6.- Concluded.

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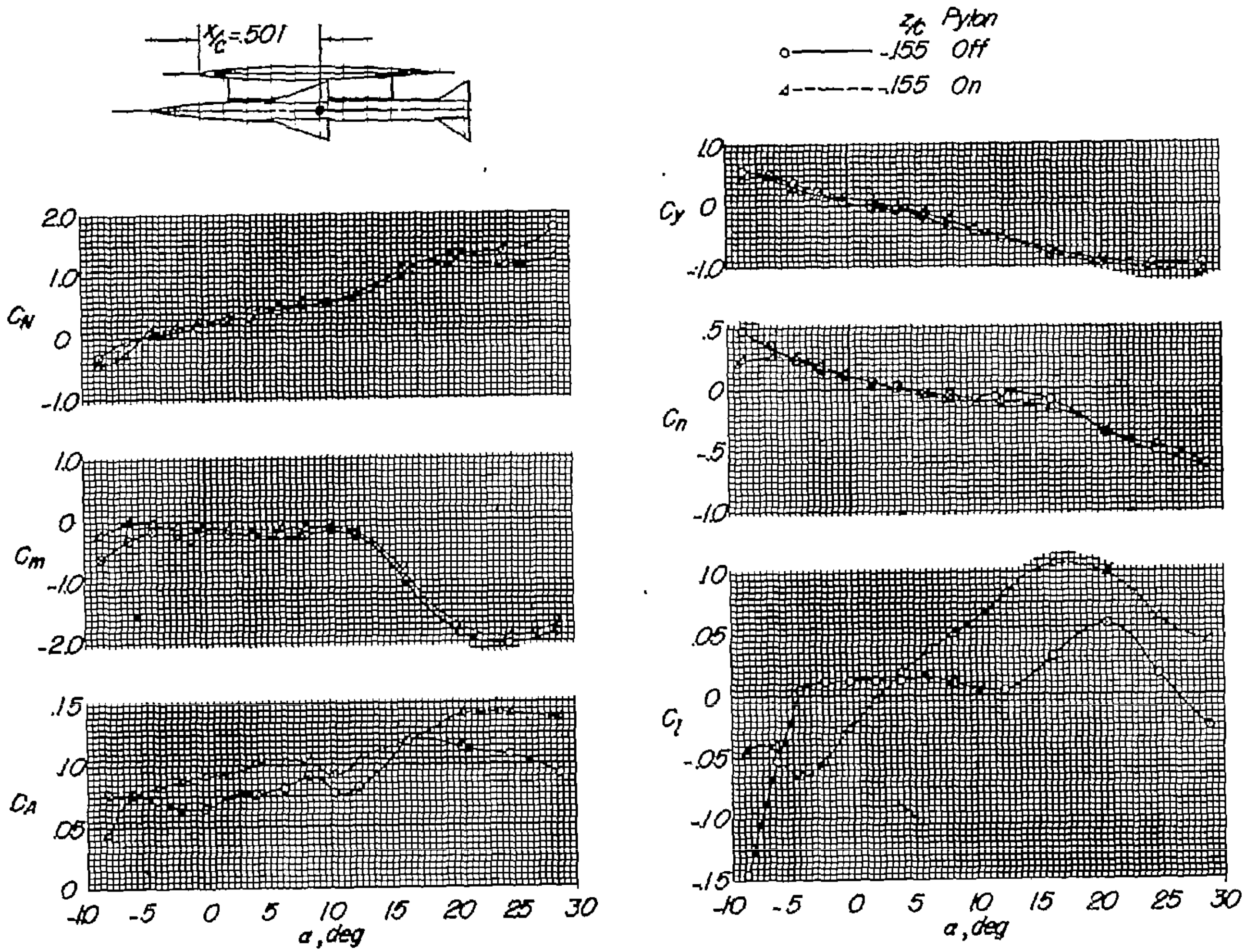
[redacted]



(a) x/c = 0.501.

Figure 7.- Missile aerodynamic forces and moments in the presence of the wing-fuselage combination with and without the pylon installed.

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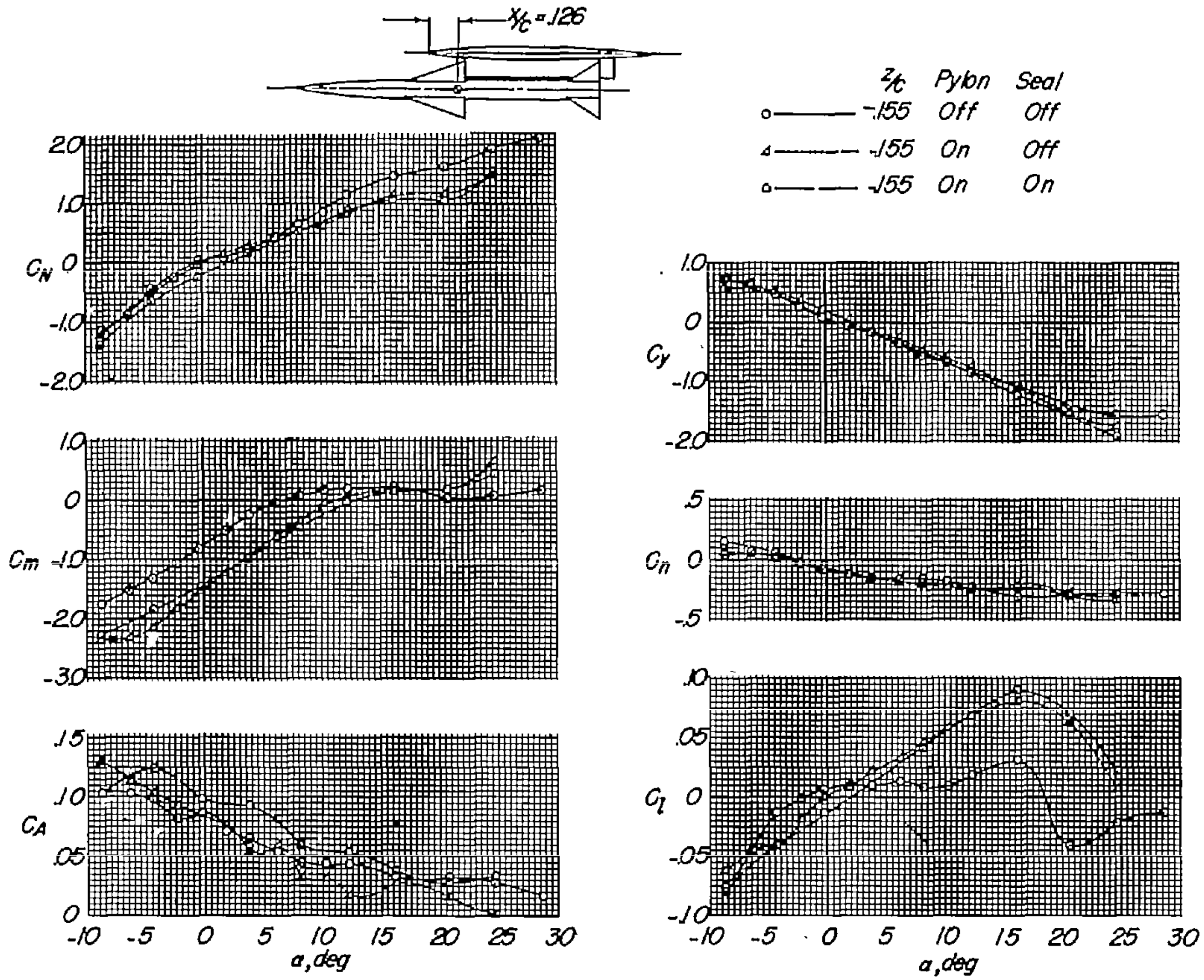

(b) x/c = 0.126.

Figure 7.- Continued.

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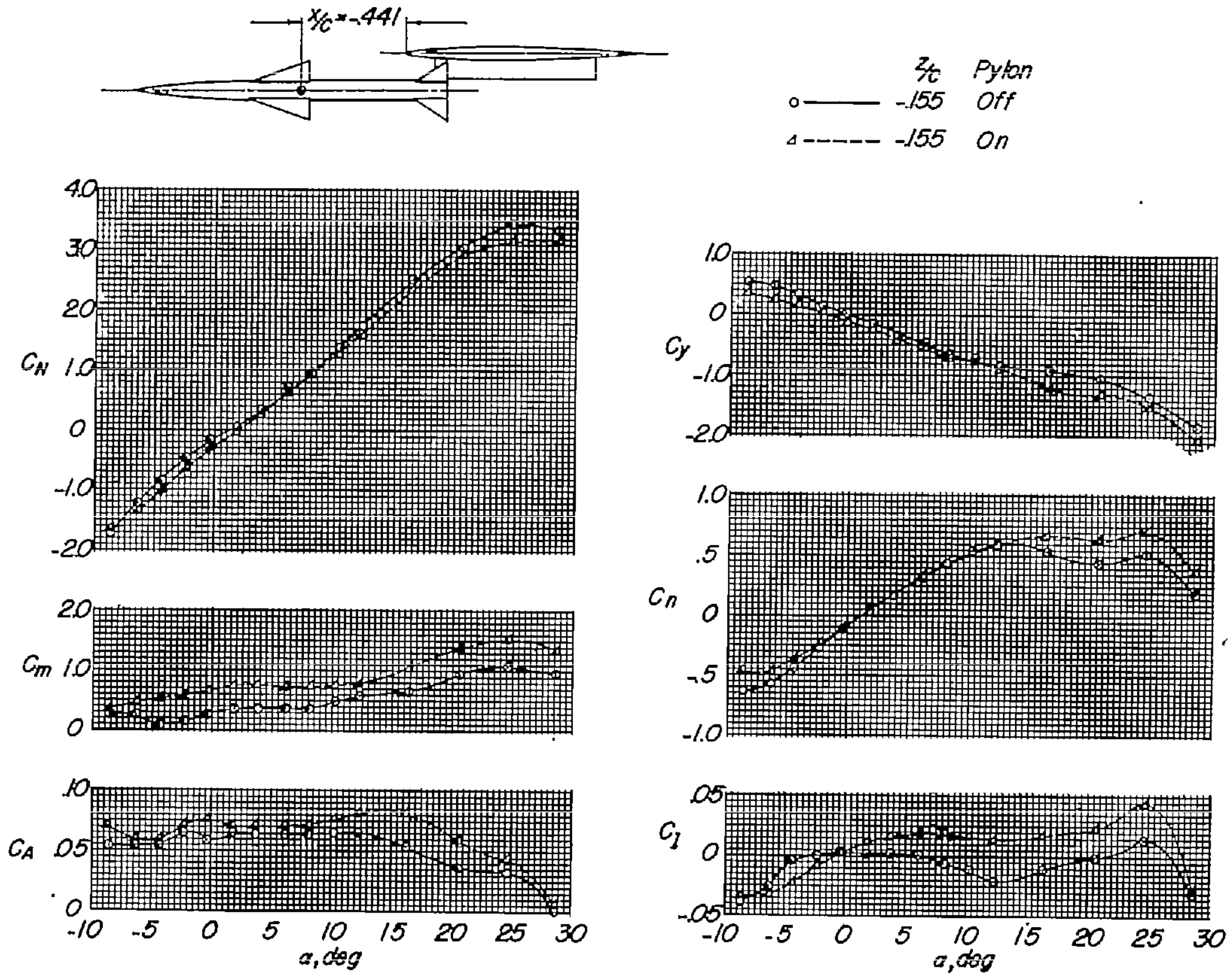

(c) x/c = -0.441.

Figure 7.- Continued.

[redacted]

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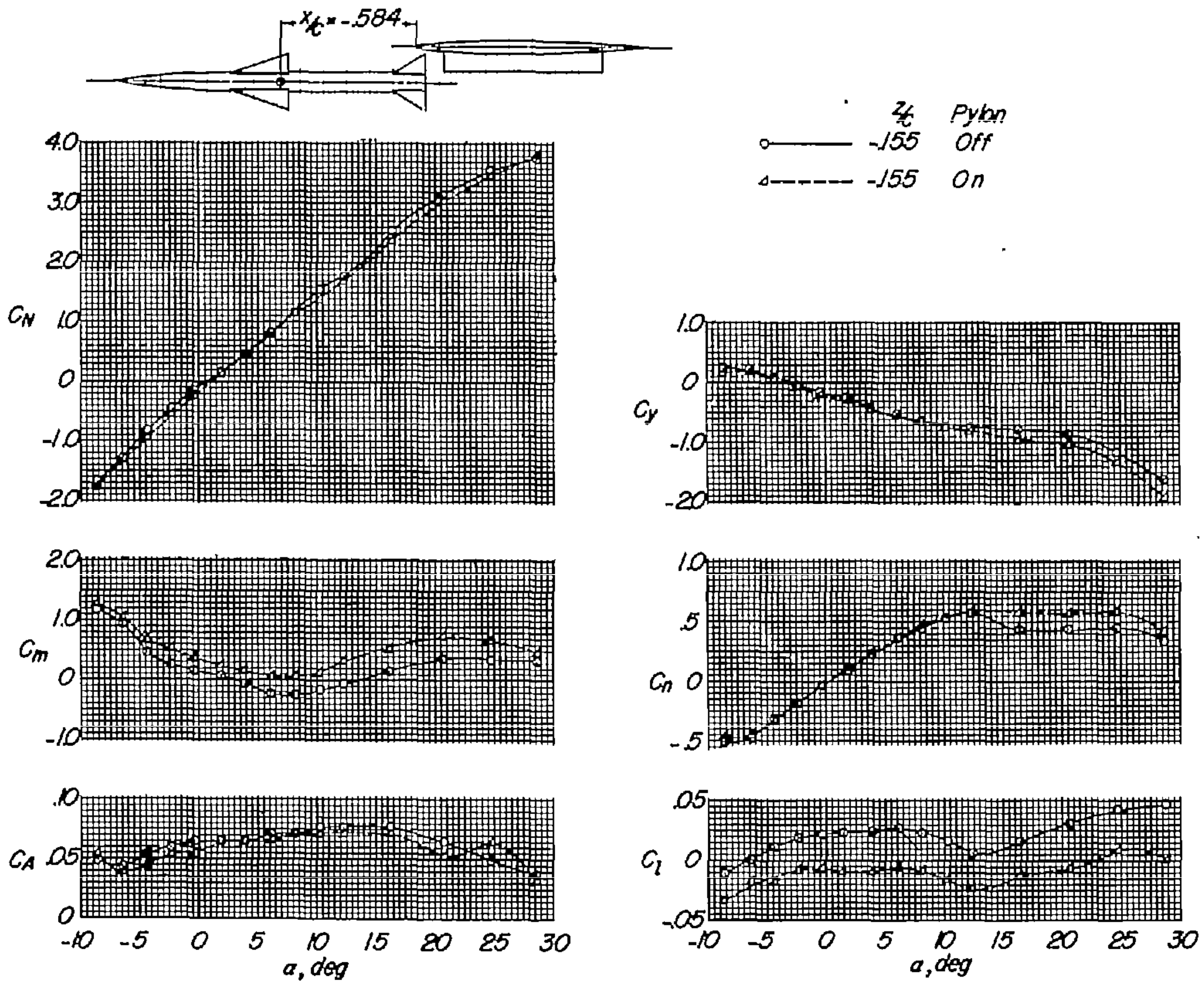

(d) x/c = -0.584.

Figure 7.- Concluded.

[redacted]

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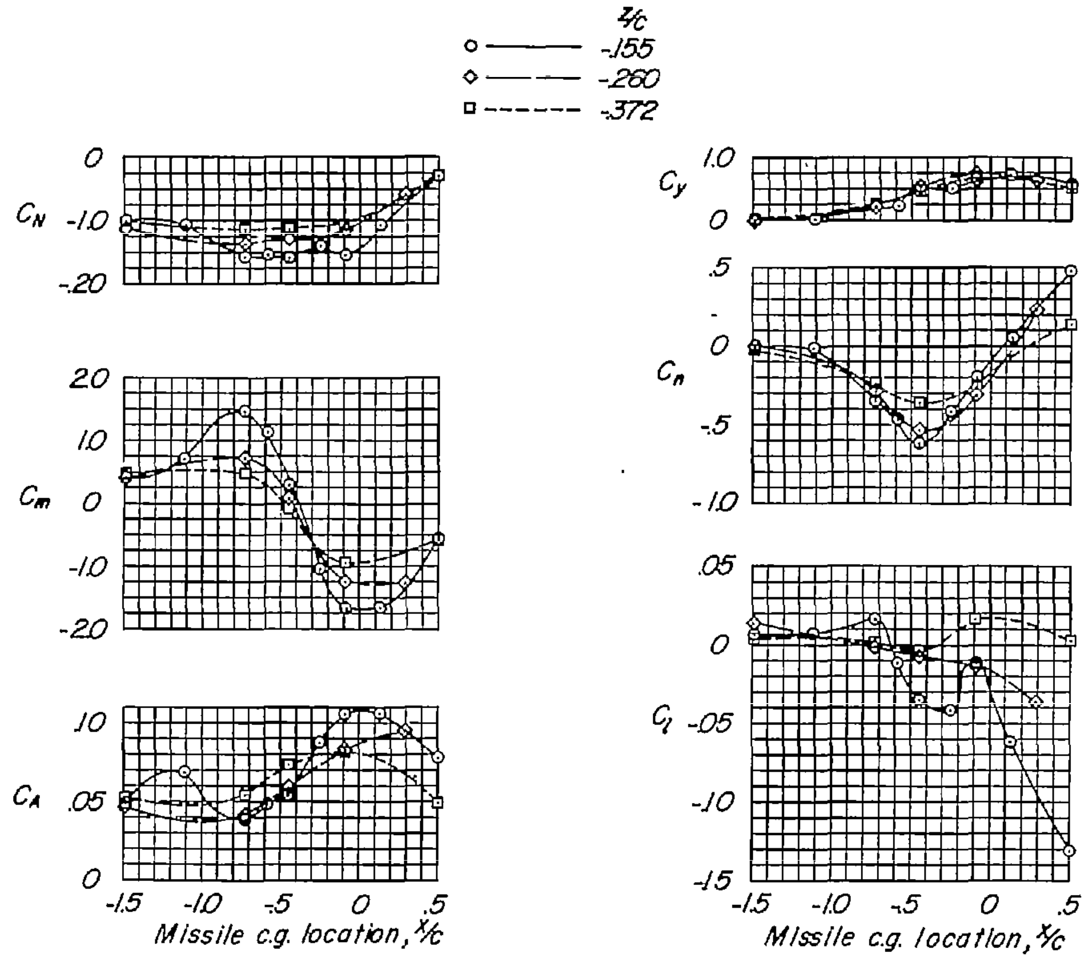

(a) $\alpha = -8^{\circ}$.

Figure 8.- Effects of chordwise position on missile characteristics in the presence of the wing-fuselage combination.

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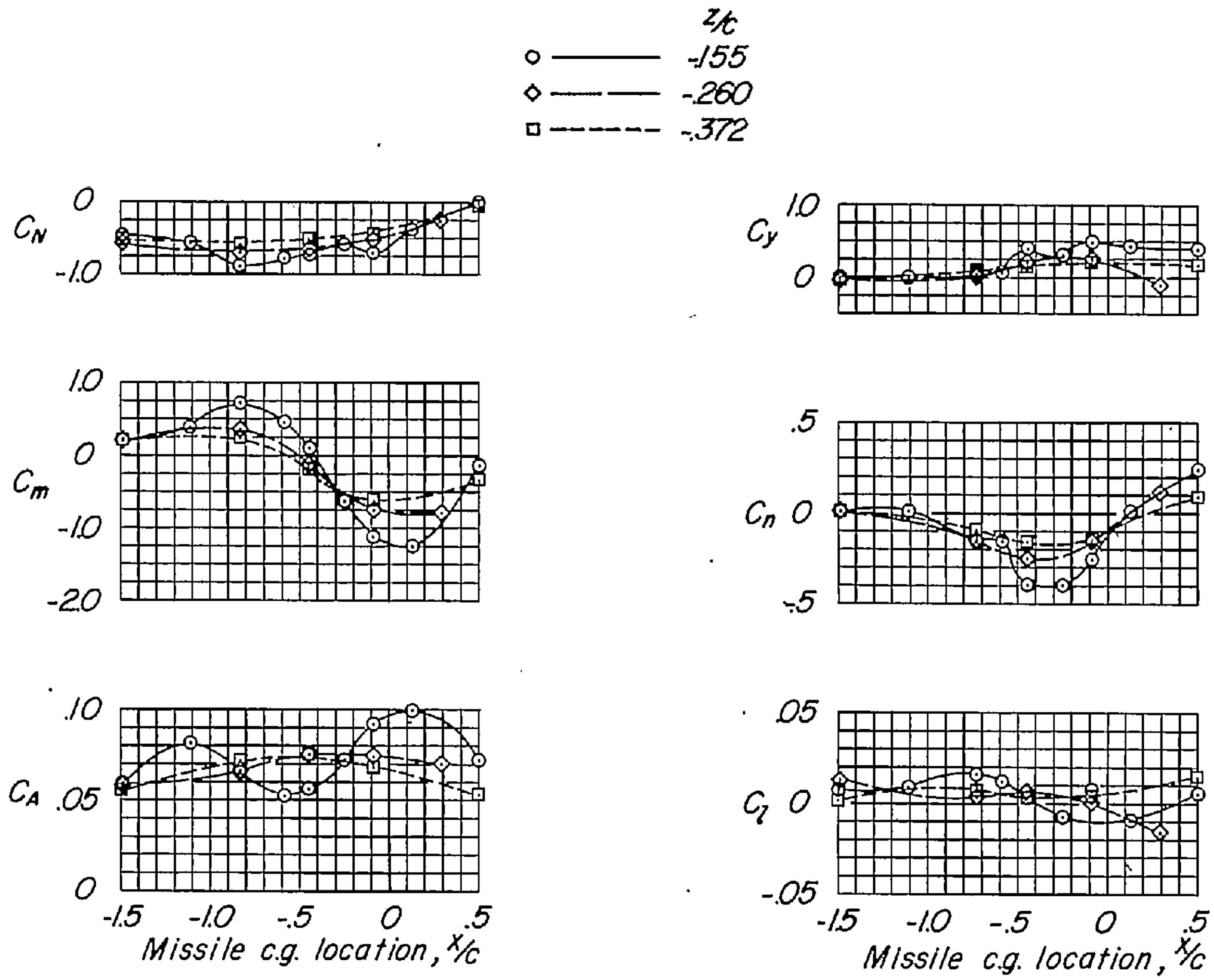

(b) $\alpha = -4^{\circ}$.

Figure 8.- Continued.

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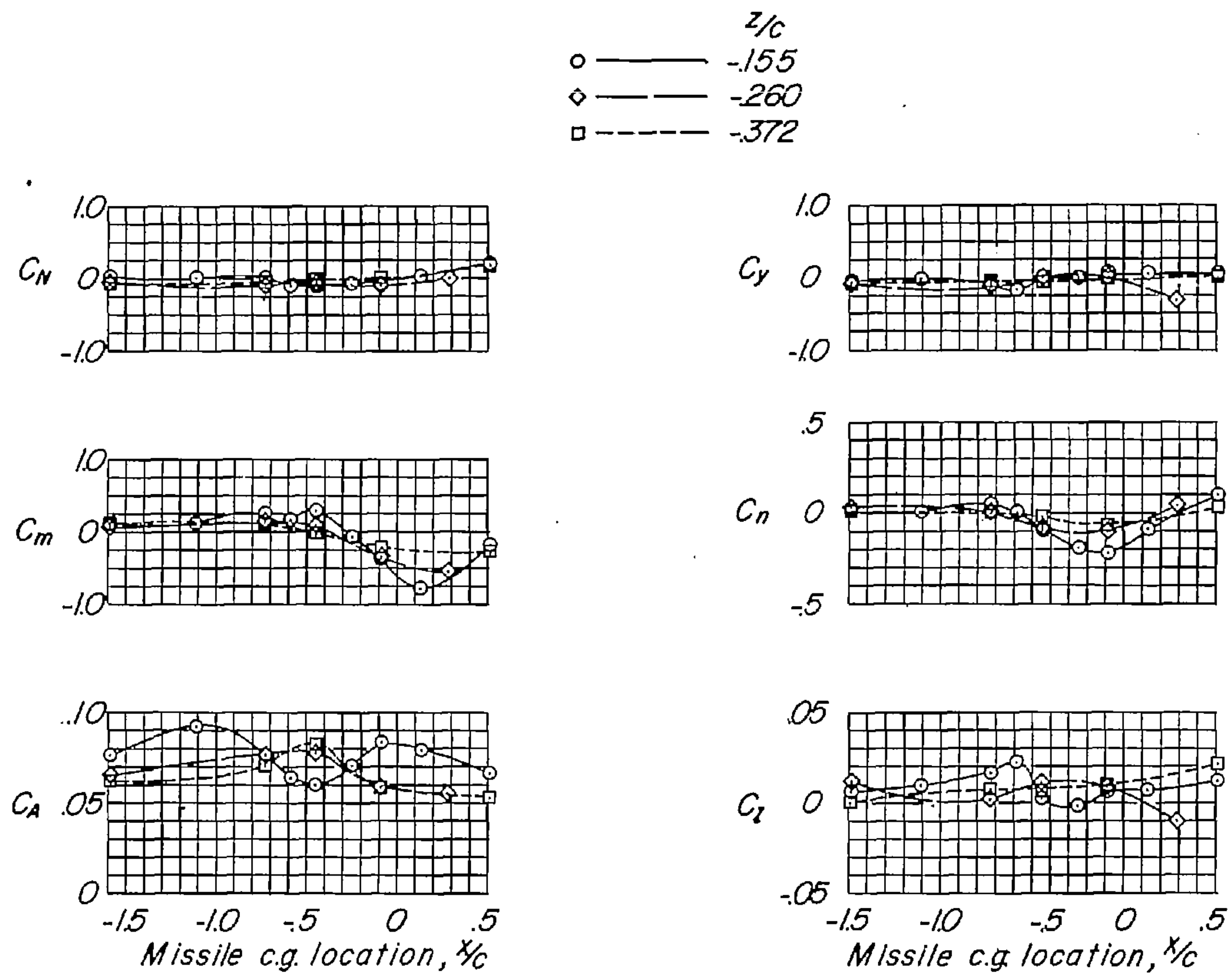
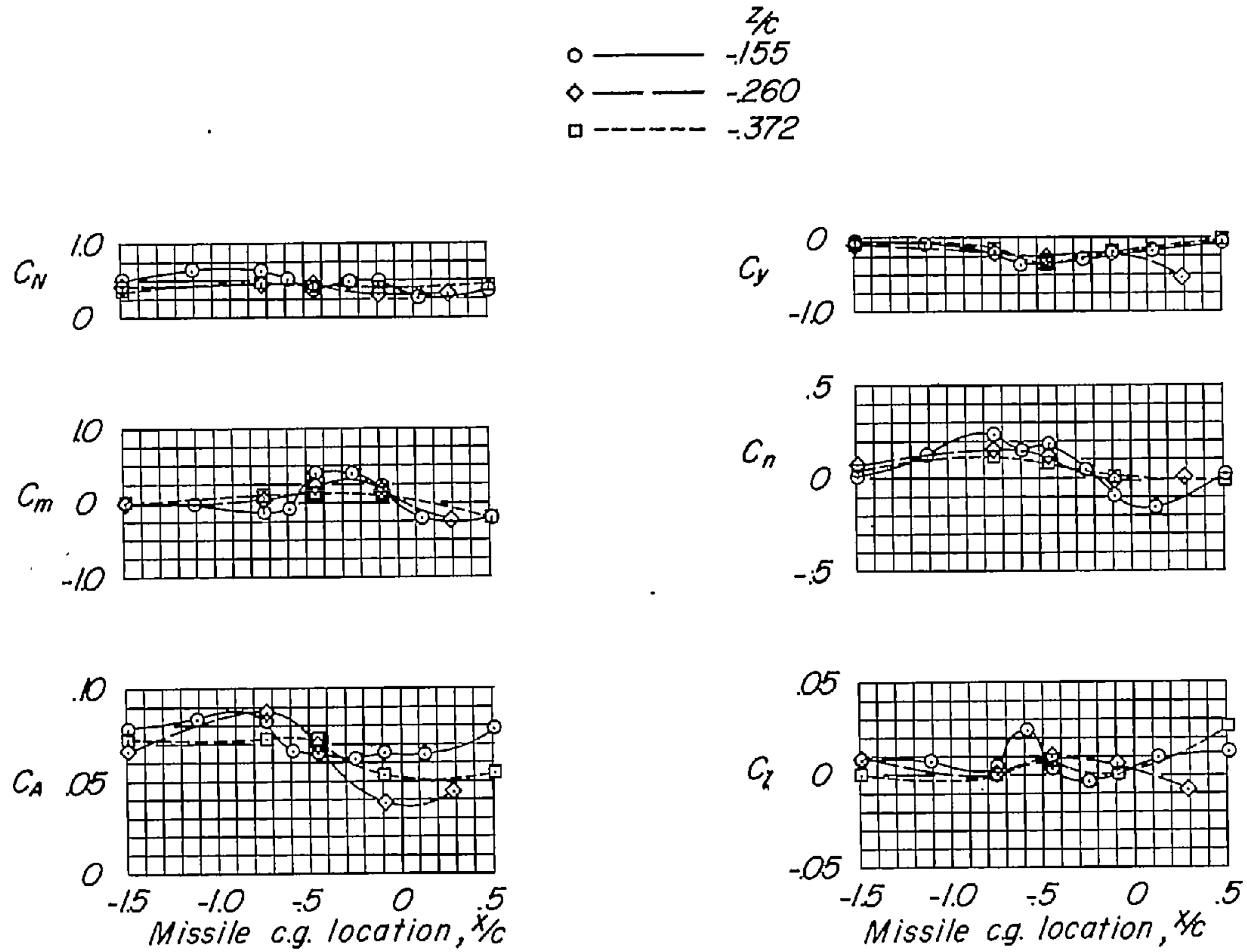


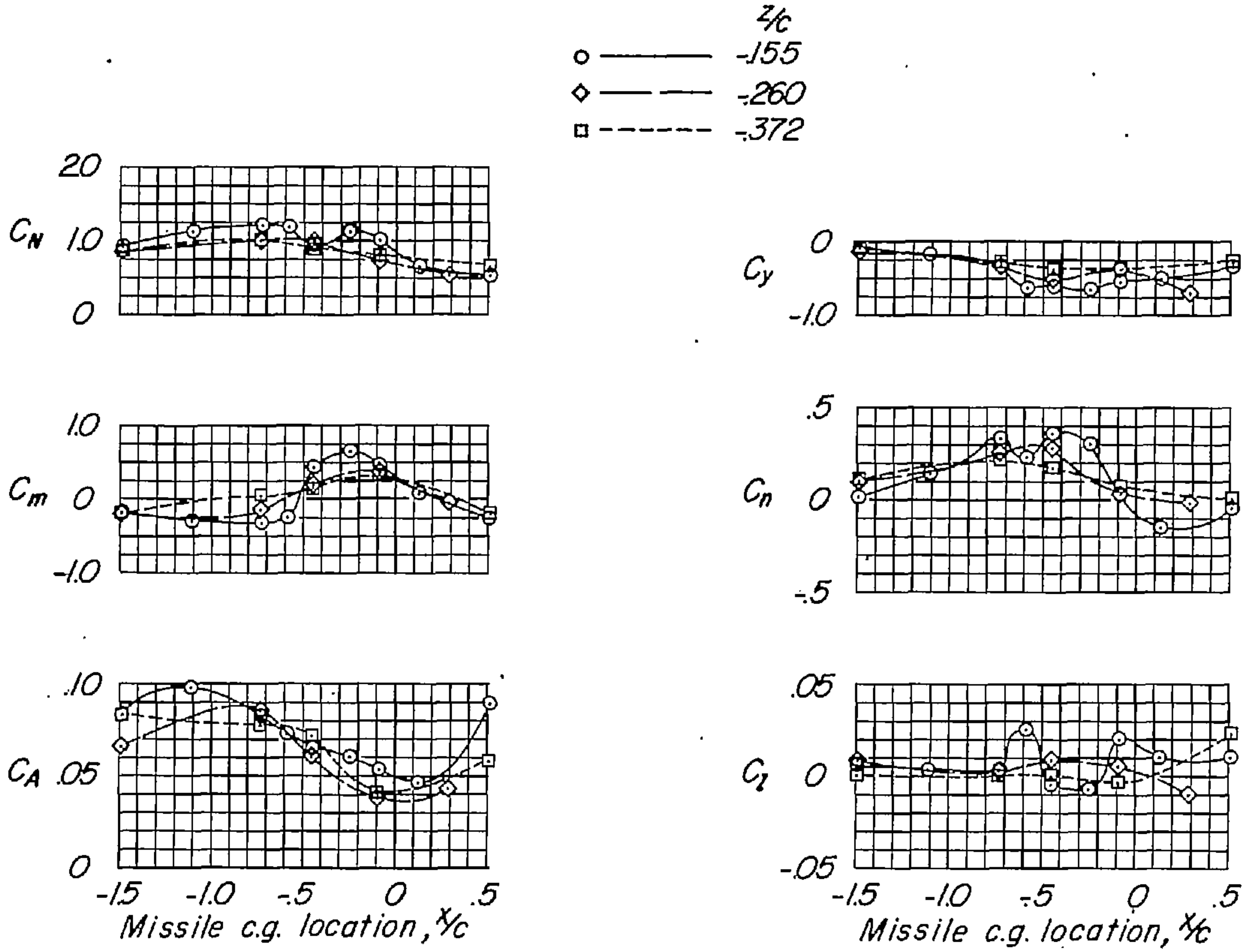
(c) $\alpha = 0^{\circ}$.

Figure 8.- Continued.



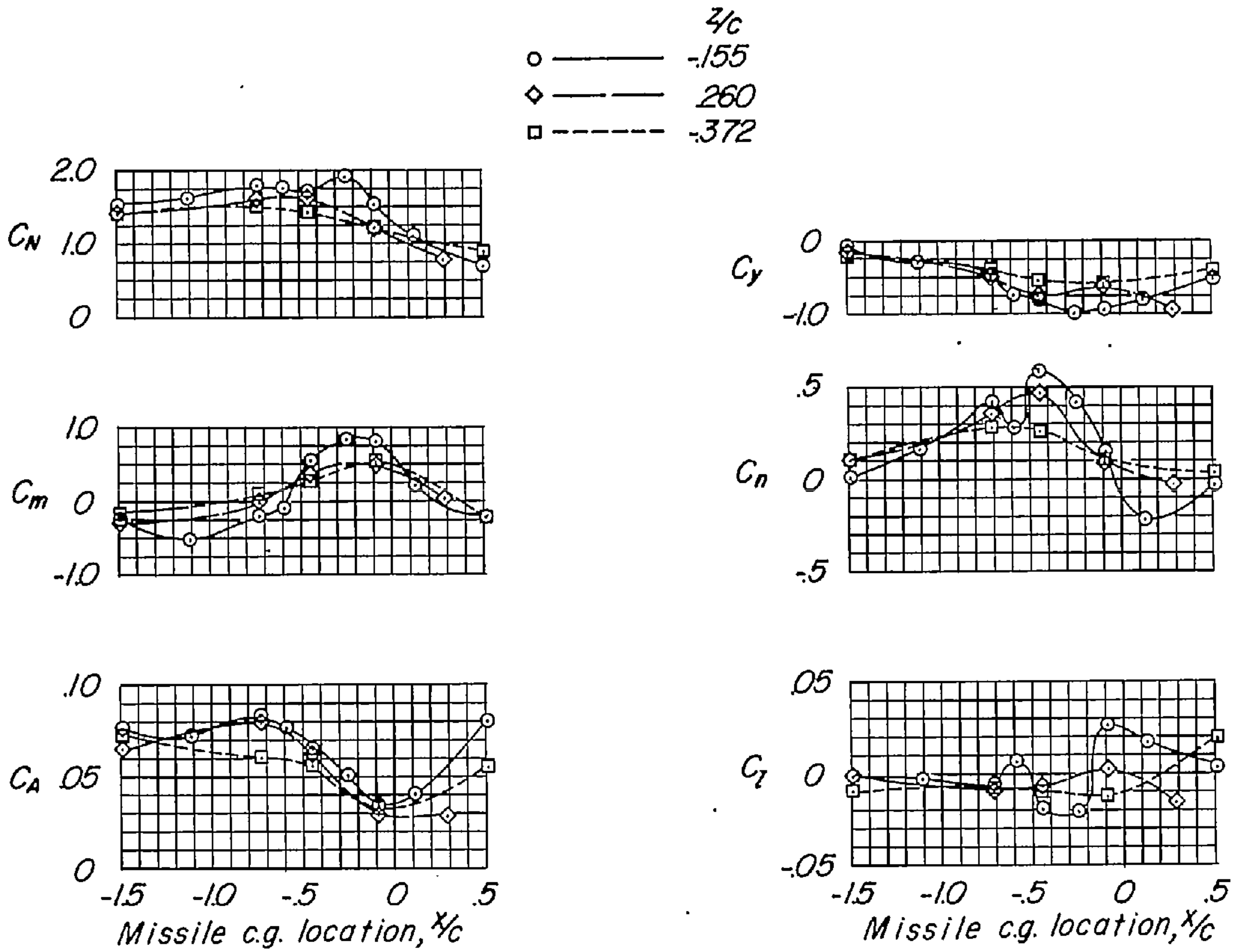
(d) $\alpha = 4^{\circ}$.

Figure 8.- Continued.



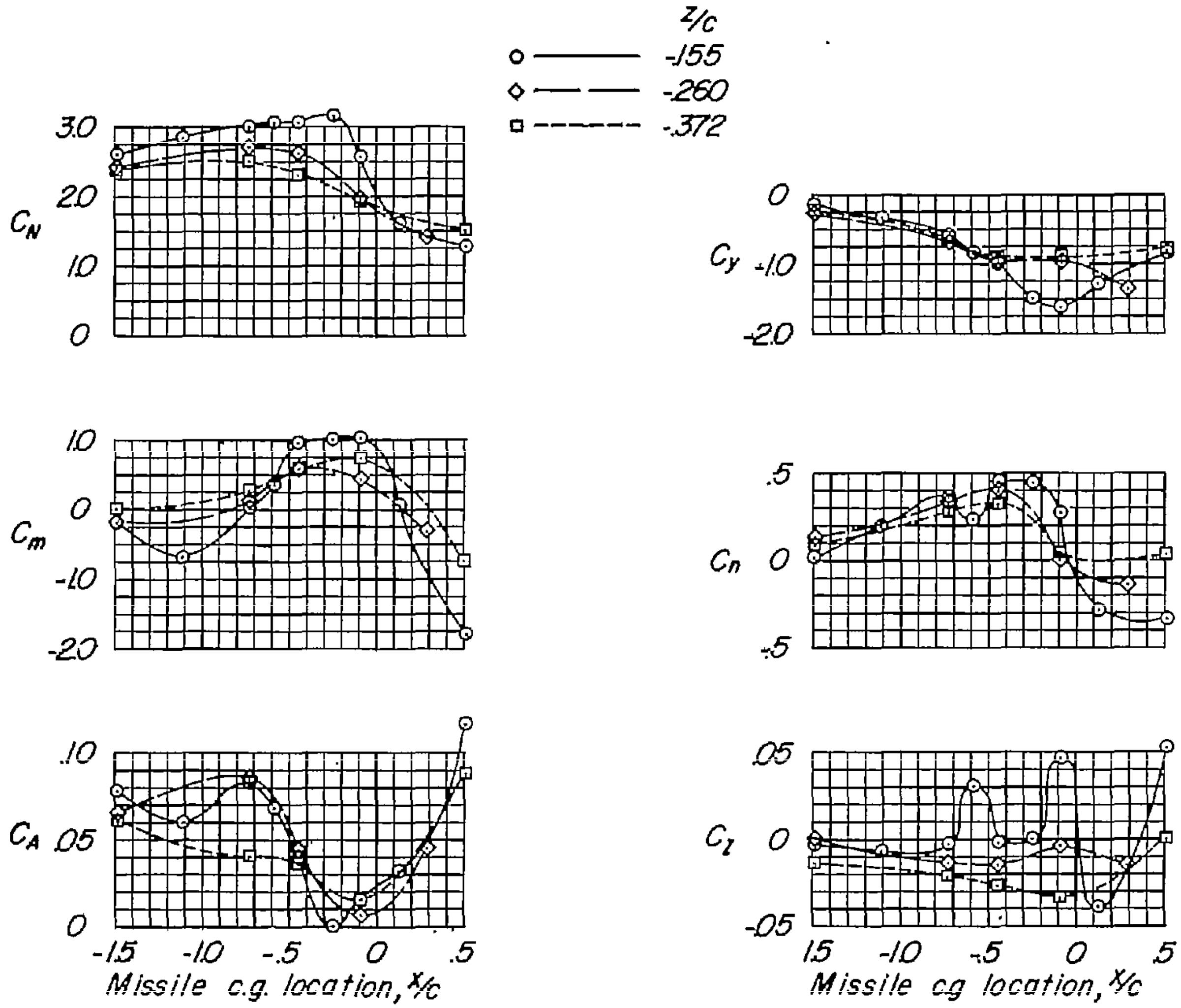
(e) $\alpha = 8^{\circ}$.

Figure 8.- Continued.



(f) $\alpha = 12^{\circ}$.

Figure 8.- Continued.



(g) $\alpha = 20^{\circ}$.

Figure 8.- Concluded.

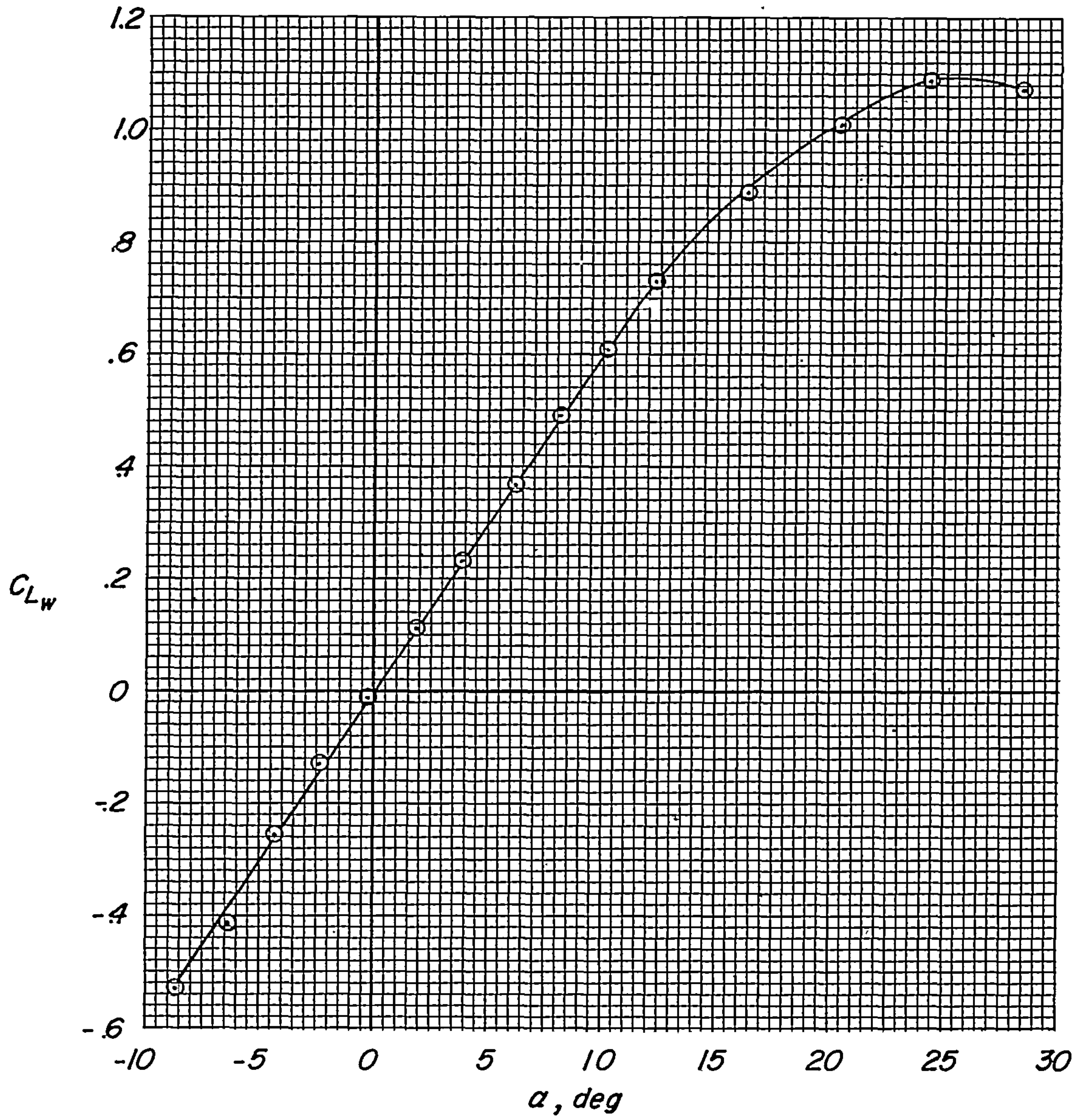


Figure 9.- Lift characteristics of wing-fuselage combination without missile.